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A Method of Measuring the Optical Sine-Wave Spatial Spectrum of Television Image Display Devices

By OTTO H. SCHADE

The method of measuring the resolution characteristic (or "spatial spectrum") of kinescopes with electrically generated sine-wave patterns has proved to give consistently accurate data at all beam currents varying from a few microamperes to several milliamperes. It is independent of the phosphor decay time and can therefore be used for measurement of color kinescope performance including the effects of misregistry. The ability to measure the response at very low "optical" (or spatial) frequencies gives numerical information on the haze and large diffusion disk surrounding the spot nucleus.

A. GENERAL PRINCIPLES

The Fourier sine-wave components of any two-dimensional optical intensity function are plane waves such as shown in Fig. 1. Their intensity distribution is specified by the amplitude and "frequency" (reciprocal wavelength) of a one-dimensional sine function (of distance, or space) and by its direction (the angle ρ). An optical sine-wave component cannot exist by itself, but requires an additive steady component (d-c level) because the total light intensity can never be negative. The Fourier relations between an electrical one-dimensional impulse function of time and its electrical spectrum are well known.[1]

The relations between a two-dimensional optical impulse, such as a kinescope light spot or point-image function of space, and its two-dimensional spatial sine-wave spectrum representation are similar and are more readily understood by considering the light spot or point-image as a *scanning aperture*. The left column of Fig. 2 shows topographic sketches of point-images, "height" representing intensity or aperture transmittance (τ). When an aperture scans an optical pattern, a phototube located behind the scanning aperture furnishes electrical signal intensities proportional to the integral of the total light flux passing through the aperture. When a line of infinitesimal width is scanned, the phototube current indicates the

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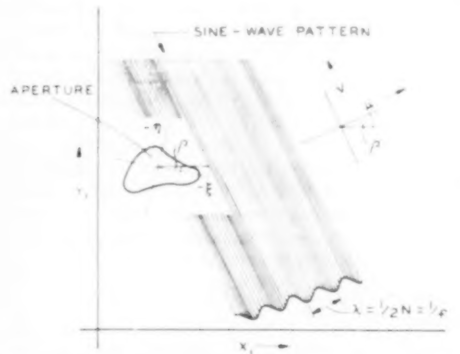

Fig. 1. Aperture scanning a sine-wave pattern.

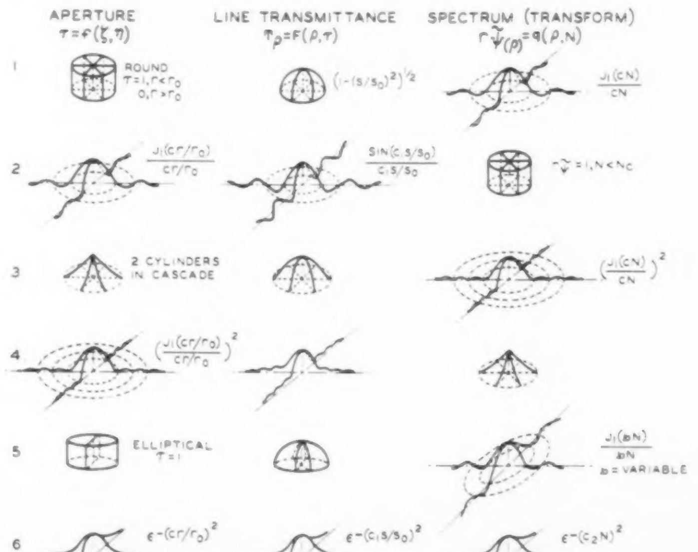

Fig. 2. Point-image (scanning aperture), line-image (impulse) and spectrum (frequency response).

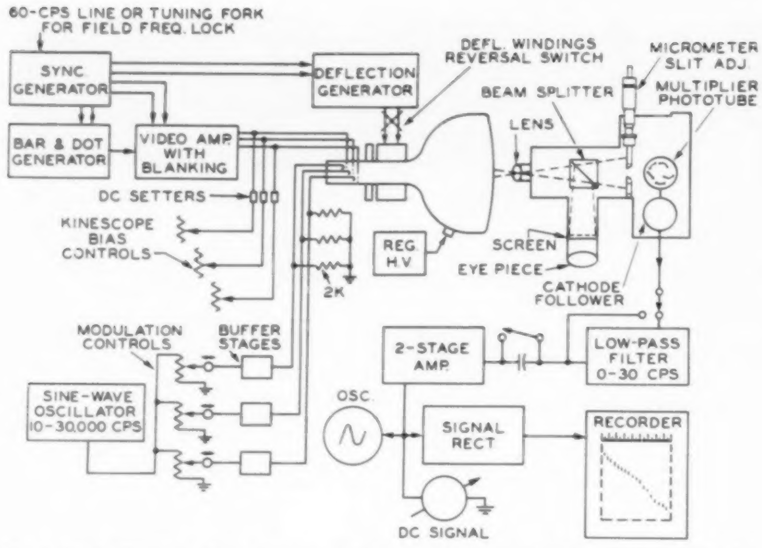

Fig. 3. Block diagram of test apparatus for measuring the sine-wave response of color kinescopes.

Fig. 4. Stationary microphotometer and optical sine-wave (plane wave) on kinescope screen.

impulse response or *line-image cross section* of the aperture as shown in the center column of Fig. 2. Because the aperture may not have circular symmetry, the impulse response is, in general, a function of the relative orientation (ρ) of the aperture to the line. The aperture, therefore, may have different spatial impulse spectra in different directions. The sine-wave spectrum in a particular direction (ρ) can be obtained by harmonic analysis of the corresponding one-dimensional spatial impulse, or it may be obtained directly by sine-wave response measurements, i.e. by scanning a set of sine-wave patterns having uniform amplitudes but different spatial frequencies as expressed by their "line-number" ($N = 2f$). The latter operation is a "convolution" of the aperture with sine waves which yields one cross section of the two-dimensional Fourier spectrum or transform of the point-image illustrated in the third column of Fig. 2.*

B. THE SINE-WAVE SPECTRUM OF KINESCOPES

Kinescopes transduce electrical signals into optical signals on a display screen. The measurement of their spatial sine-wave spectrum requires three basic pieces of test apparatus: (1) a generator of electrical test signals which, when transduced by the kinescope, are displayed as optical plane waves; (2) a suitable beam deflection, retrace blanking and energy supply system; and (3) a microphotometer to measure and record optical amplitudes on the kinescope screen. A block diagram of the test apparatus is shown in Fig. 3.

* A more detailed discussion of this subject may be found in Ref. 1.

1. Test Signal and Pattern Displacemen

The signal-type and beam-deflection methods (items (1) and (2) above) are interdependent. When a standard parallel-line-raster scan is used without interlace, stationary plane-wave patterns (see Fig. 4) are generated in a direction across the lines when the modulating input signal is a pure sine wave having a frequency f_m which is an integral multiple (p) of the field frequency f_f. A continuous vertical displacement or drift of constant velocity is imparted to the optical plane wave on the kinescope screen by selecting nonintegral frequency multiples

$$f_m = pf_f \pm f_d \qquad (1)$$

where f_d is the drift frequency in cycles per second. It is apparent that the modulating frequency can be given many different values maintaining a constant frame frequency and drift frequency, thereby effecting a translation of different spatial frequencies on the kinescope screen into one fixed temporal frequency (f_d) of light-intensity variation with respect to a fixed point on the kinescope screen.

The spatial frequency f of the plane wave is usually expressed by the television line-number $N = 2f$ in lines per unit length and may be computed from

$$N = 2(n_r/n_s)\,(f_m/f_f)/V \qquad (2)$$

where n_r/n_s = ratio of total raster line-number, n_r, to the number n_s, of unblanked or visible raster lines. V = vertical frame dimension. *For example:*

$f_f = 60$ cycles/sec, $n_r/n_s =$ 0.9 and $V = 4$ in.

When $f_d = 12$ cycles/sec, with values $p = 1$ and $p = 10$, Eq. (1) gives the modulating frequency $f_{m1} = 72$ or 48 cycles/sec and $f_{m10} = 612$ or 588 cycles/sec, respectively, and Eq. (2) gives the plane-wave line-numbers $N_1 = 0.54$ or 0.36 lines/in. and $N_{10} = 46$ or 44.1 lines/in.

The frequency conversion to a fixed low-frequency value f_d is essential for several reasons. Temporal integration of light-intensity variations by a phosphor time-constant reduces the amplitude response of an observing microphotometer but it does not affect the indicated amplitude of optical plane waves having different line-numbers relative to one another when the temporal drift frequency is held constant. Temporal integration causes then merely a signal reduction by a constant factor.

The electrical pattern displacement generated by a nonintegral frequency relation between f_m and f_f permits observation of the sine-wave response at any fixed point on the kinescope screen, eliminating errors due to phosphor screen nonuniformity and removing displacement limitations which restrict other methods to frequencies well above $N = 0$. The lowest modulation frequency is equal to the drift frequency ($p = 0$ in Eq. (1)) and the minimum line-number for the above example is $N_{min} = 0.36/V = 0.09$ lines/in. The response at N approaching zero is important to establish a true relative amplitude scale and to measure the initial decrease in response caused by large haze disks which may surround a fine spot nucleus because of optical or electrical diffusion.

2. Elimination of Raster Effects

The electrical plane-wave signal intensity perpendicular to a line raster is not continuous. It is the modulation envelope of a unidirectional optical pulse carrier wave having the fundamental spatial frequency $f_1 = n_r$. Elimination of unwanted sidebands ("beats") requires that both the spatial modulation frequency and the optical passband $f_c = N_c/2$ of the kinescope be limited to one-half the carrier frequency n_r, i.e. to line-number

$$N_c \leqq n_r \text{ TV lines.} \quad (3)$$

The electrical modulation frequency must hence be limited to f_m = one-half the horizontal deflection frequency, and the vertical raster dimension (V) must be adjusted so that the kinescope will not resolve the line-number $N_c = n_r$. This condition is obtained by reducing V to one-half the value giving a "flat" field with zero modulation.

To prevent screen burn by too small a vertical size, practical values for the horizontal deflection frequency are in the order of 30 kc (double normal) giving approximately a 500-line noninterlaced raster. Interlacing cannot be used because it produces two plane-wave images displaced by one line-space from one another.

Measurements at very high current values such as occur in projection tubes can be made without damage to the electron gun or phosphor by applying a square-topped positive pulse wave during the horizontal retrace, which blanks out the normal raster and leaves only the retrace raster. The duty factor is thus easily reduced to less than 10% and a fully scanned raster is obtained on the kinescope screen at less than 0.1 normal brightness. The applied horizontal pulse wave must contain a vertical blanking interval to suppress vertical retrace lines on the screen. The peak beam current can be measured with an oscilloscope on the cathode resistor (see Fig. 3) when the sine-wave modulation is turned off. (The keying pulse wave is applied to the control grid.)

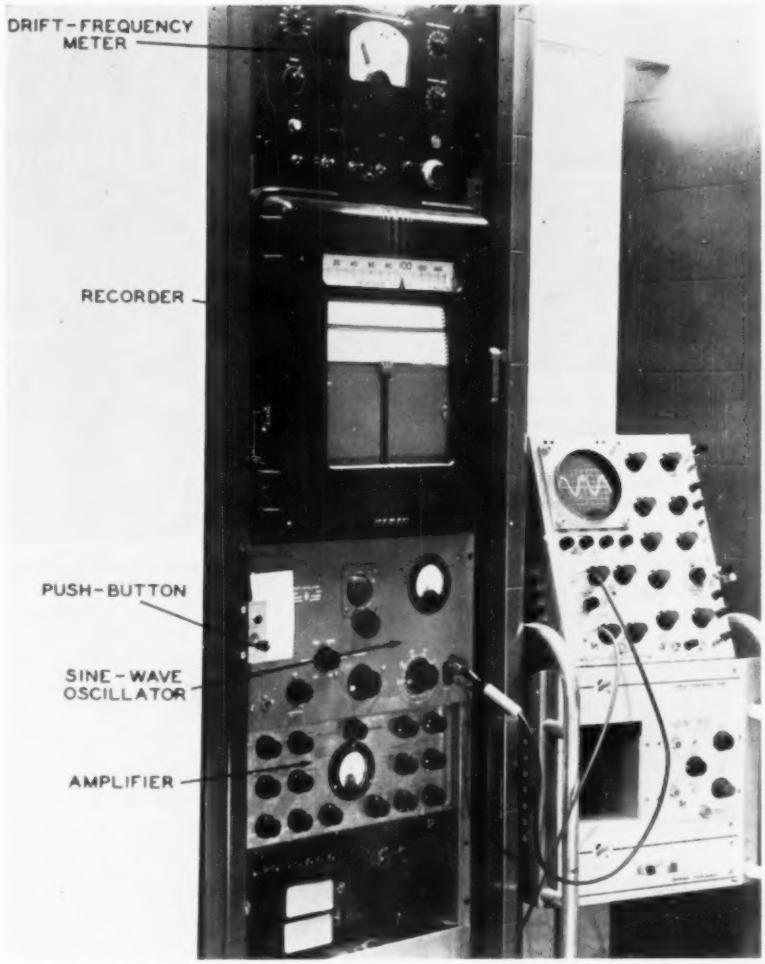

Fig. 5. Electrical signal source, amplifier and metering apparatus for microphotometer.

3. Modulation Amplitudes

To prevent waveform distortion by the nonlinear transfer characteristic of the kinescope, the optical sine-wave modulation must be restricted to small values. The amplitude of the optical sine wave should not exceed 15% of the average light level. This modulation level, furthermore, does not cause an appreciable distortion of the kinescope beam diameter which is generally a function of current. The optical modulation depth is observed with the d-c-responsive microphotometer (see below) by reading the amplitudes of a very slowly drifting low-frequency pattern (61 cycles/sec). The electrical sine-wave signal is generated by a stable (RC-type) audio oscillator and injected into the cathode circuit of the kinescope as shown in Fig. 3. Adjustable blanking signals or pulse signals are introduced in the grid circuit to set the desired beam current and average light level. The block diagram illustrates an arrangement for separate or simultaneous sine-wave response measurement of a color kinescope (or a 3-tube color projector) requiring *synchronous modulation* of its three beam currents.

For white-light sine-wave response measurements, the three d-c bias values and/or grid signals are adjusted to give the desired color temperature and currents. The relative modulation amplitudes required for the three guns depend on the desired overall spectral response. For measurement of the "luminance" response, the modulation is adjusted at the lowest line-number and the selected drift frequency for one gun at a time to give microphotometer readings having the appropriate luminance ratio; while for constant energy response, the relative modulation values are adjusted to give equal readings.

It is evident that the required modulation percentages may differ substantially from those producing a "white" sine-wave pattern on the kinescope screen because the described adjustment automatically provides compensation for different phosphor decay times, and for the spectral response of the microphotometer which is, therefore, not critical. It is, however, practical to equalize the microphotometer response roughly by use of a color filter (amber for luminance readings) to avoid large differences in modulation amplitudes. The calibration changes with drift frequency which, therefore, must be held constant throughout a measurement series by proper choice of oscillator frequencies.

4. Photometric Signals

The optical pickup unit of the microphotometer (see Figs. 3 and 4) contains an achromatic microscope objective having a focal length of either 45 or 32 mm forming an image magnified 2 or 6 times, respectively, of the kinescope screen surface on the adjustable slit in front of a 2P21 multiplier phototube. A portion of the image light is diverted by a beam-splitting glass cube to a reticle for optical observation and focusing through an eyepiece lens. The multiplier phototube current develops a signal voltage on a 5-megohm plate load fed through a cathode follower and a coaxial cable to the main amplifier unit (Fig. 5), containing a 5-section low-pass filter (0 to 25 cycles/sec), a two-stage d-c amplifier, and a phase

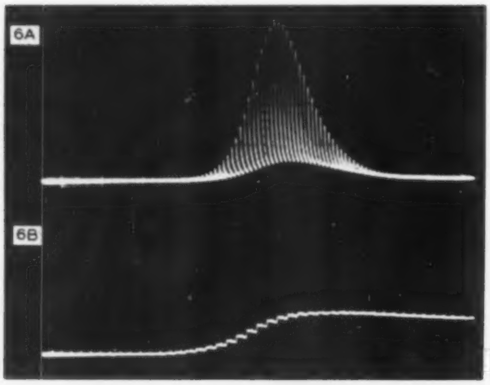

Fig. 6. Line-image waves distorted by phosphor time constant: A, short-decay phosphor; B, long-decay phosphor.

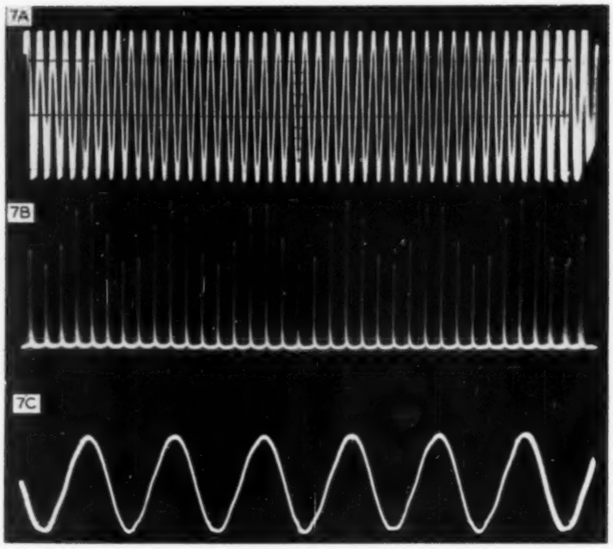

Fig. 7. A, electrical sine-wave input; B, drift frequency samples before filtering; C, drift frequency after filtering.

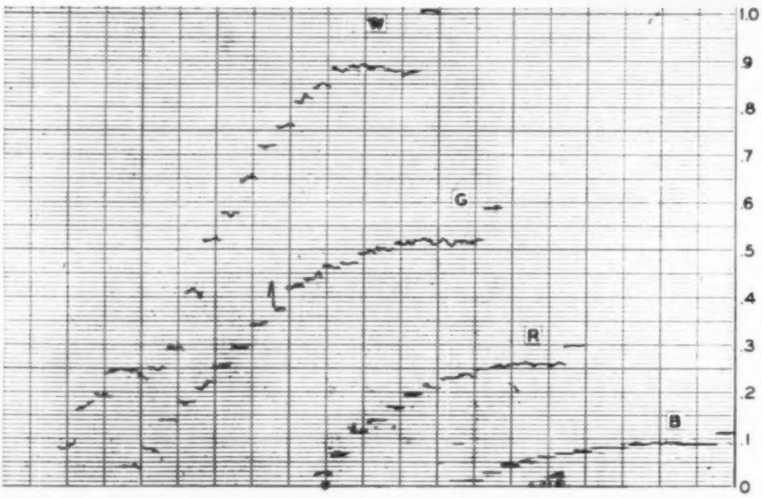

Fig. 8. W, luminance response of color kinescope; G, R, B, luminance response of green, red and blue components.

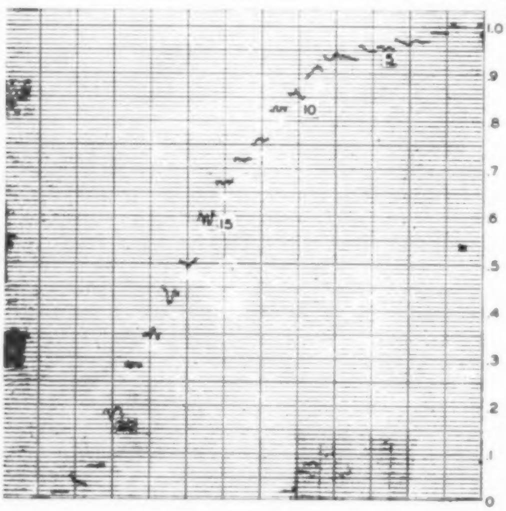

Fig. 9. Sine-wave response of high definition kinescope.

Step No.	*Oscill. Freq. cycles/sec*	*Line-No. N/in.*
1	70	3.1
2	130	5.8
3	250	11.1
4	370	16.5
5	470	20.8
6	610	27.0
7	730	32.4
8	910	40.3
9	1210	53.7
10	1510	67.0
11	1810	80.5
12	2290	101.0
13	2650	117.0
14	3010	133.0
15	3610	160.0
16	4210	187.0
17	5050	224.0
18	5410	240.0
19	6010	266.0
20	7210	320.0
21	9010	400.0
22	10510	466.0
23	12010	532.0
24	off	

splitter followed by a full-wave rectifier.

The phototube signal obtained from a fast-decay sulfide phosphor in one field period with zero modulation and without the low-pass filtering is shown in Fig. 6A. The pulse envelope is the impulse response of the kinescope, slightly distorted by the phosphor decay; the individual pulses are the light-amplitude samples taken in successive scanning lines. When the phosphor decay is longer (green willemite), the impulse response becomes badly distorted by integration as shown in Fig. 6B.

With a sine-wave-modulated field drifting at a fixed slow rate (12 cycles/sec) over the microphotometer slit, however, this integration does not affect the accuracy of measurement, because the selected modulation frequencies (Fig. 7A) are transposed always into the same slow drift frequency (12 cycles/sec) which becomes the modulation envelope of the impulse-response group as shown in Fig. 7B. The time between the "spikes" formed by the partially integrated impulse groups of Fig. 7B is that of one field ($\frac{1}{60}$ sec), and the modulation amplitude is proportional to the optical sine-wave amplitude on the kinescope screen. Integration of all frequencies above the drift frequency by the low-pass filter eliminates the pulses as shown in Fig. 7C and yields a (12-cycles/sec) sine-wave signal retaining a relative amplitude proportional to the optical sine-wave amplitude on the kinescope screen. Rectification of this signal furnishes a d-c voltage for operation of a meter or a Speedomax recorder. Typical recorder traces are shown in Figs. 8 and 9.

5. Recording Procedure

The sine-wave amplitude response is measured in discrete steps at the frequencies listed in Fig. 9. The Speedo-

max recorder was therefore equipped with a pen-lifter and a magnetic clutch in the paper-drive gear train, so that the pen does not write during oscillator-frequency adjustments. The drift frequency is indicated by a frequency meter (see Fig. 5), but it can be monitored by adjusting for a stationary one-cycle sine-wave trace on a stable free-running oscilloscope (see Fig. 5). After each frequency adjustment, the pen-lifter and paper-drive magnets are actuated by depressing a pushbutton switch. The recorder pen writes the rectified d-c signal amplitude for a short time ($\frac{1}{2}$-in. trace length) until one of the paper-drive gears completes one revolution and breaks the relay holding circuit by opening a microswitch contact. The total time required for frequency adjustments and the intermittent recording of a twenty-four point response characteristic is approximately two minutes.

Measurement of the complete sine-wave spectrum of a kinescope light spot requires variation of the scanning direction. This variation is readily accomplished in monochrome kinescopes by rotating the deflecting coils on the neck of the tube, but it is not practical in color kinescopes where the scanning directions (h and v) have a predetermined relation to the color raster. In this case, a stationary deflecting coil having similar horizontal and vertical deflection coil inductances can be used for scanning in two perpendicular directions by interchanging electrical connections. When such a tube is measured, the slit of the microphotometer should be set at a small angle to a row of like color dots so that it covers one complete cycle of positions relative to the dots beginning, for example, at a dot center of one row and ending at a dot center of an adjacent row. This position will make the response independent of the scanning raster position on the screen, i.e. the "centering" adjustments. The scanning lines are, of course, set parallel to the microphotometer slit by slight rotational adjustment of the deflecting coils.

6. Reconstruction of the Kinescope Light Spot

The Fourier relations for the general case of a noncircular scanning aperture or point-image causing phase shift are illustrated in Fig. 10. The aperture spectrum can be represented in a number of ways: (a) by its amplitude solid and phase solid; (b) by its cosine coefficient solid and its sine coefficient solid (as illustrated); and (c) by a single composite solid which is the *arithmetic* sum of the cosine and sine solids (illustrated). The composite spectrum solid and the aperture are reversible, i.e. *an aperture having the form of the composite spectrum solid has a spectrum having the form of the aperture solid.* This unconventional composite spectrum representation is based on the following relations.

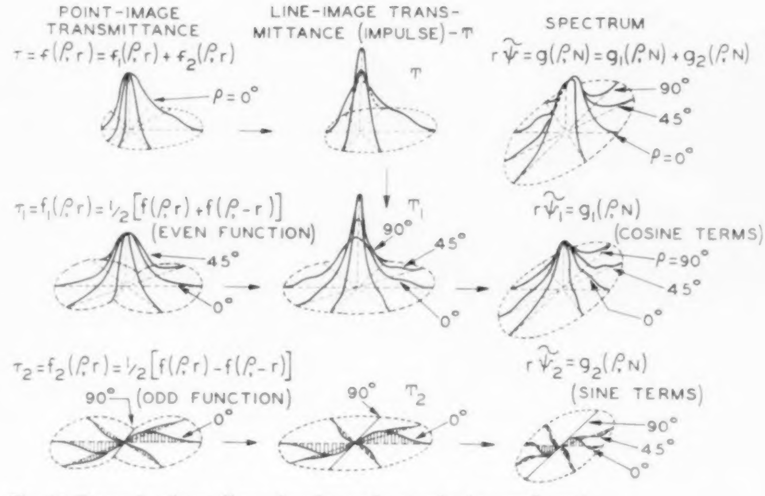

Fig. 10. Example of two-dimensional transform pairs (general case).

The conventional cosine and sine spectra can be obtained by first computing each cross section of the "composite" line transmittance solid by the integration $\mathrm{T}_\rho = F_\rho(x) = \int_{-\infty}^{\infty} \tau \, dy$ shown in the top row of Fig. 10, then decomposing each line transmittance (axial cross section) into an even and odd function (corresponding axial cross sections of the solids T_1 and T_2), which by harmonic analysis yield the cosine and sine spectra, i.e. corresponding cross sections of the sine and cosine spectrum solids. Or, one may decompose the aperture solid into its even and odd function solids, and compute from them the even and odd line-transmittances T_1 and T_2 and the even and odd function spectra. Any axial cross section can be expressed as a function of a radius r, and a composite function $f(r)$ is the sum of its even and odd components:

$$
\begin{aligned}
& f(r) = f_1(r) + f_2(r) \\
\text{with} \quad & f_1(r) = \tfrac{1}{2}\,(f(r) + f(-r))\,(\text{even}) \qquad (4) \\
\text{and} \quad & f_2(r) = \tfrac{1}{2}\,(f(r) - f(-r))\,(\text{odd})
\end{aligned}
$$

It follows that for $r \equiv N$, the composite spectrum is the sum of the even (sin) and odd (cos) spectra

$$g(\rho, N) = g_1(\rho, N) + g_2(\rho, N) \qquad (5)$$

This process of analysis is completely reversible as stated above.†

The measured kinescope spectrum gives no information on phase shift, which can therefore be omitted in a practical analysis. The labor of performing a two-dimensional Fourier analysis can be reduced considerably by the use of a synthesis in which partial transforms are summed as follows. The measured sine-wave spectrum $g(N)$ is decomposed into a sum of (n) spectra of known shape:

$$g(N) = a_1 g_1(N) + a_2 g_2(N) + \ldots + a_n g_n(N) \qquad (6)$$

where a_1 to a_n are the amplitude scale factors at $N = 0$, their sum equaling unity. Because of the linearity of the Fourier transformation, *the intensity function of the one-dimensional impulse or line-image cross section is then the sum:*

$$F(x) = a_1 F_1(x) + a_2 F_2(x) + \ldots + a_n F_n(x) \qquad (7)$$

where the component intensity functions $F_1(x)$, $F_2(x)$, . . . and $F_n(x)$ are known *one-dimensional* inverse transforms of the component spectra in Eq. (4) and a_1 to a_n are the amplitude scale factors at $x = 0$, having the same values as in Eq. (6). It is pointed out that the line-image cross section is *not* the cross section of the kinescope light spot (aperture) as illustrated in Fig. 2.

The intensity function along one cross section of the two-dimensional kinescope spot can be determined from a one-dimensional spectrum sum as expressed by Eq. (6) and synthesized similarly as a sum:

$$f(r) = a_1 f_1(r) + a_2 f_2(r) + \ldots + a_n f_n(r) \qquad (8)$$

where the component functions are known *two-dimensional* inverse transforms of the spectrum components in Eq. (6).

It therefore follows, for example, from Fig. 2 that the line-image cross section $F(x)$ will be a sum of $(\sin x)/x$ functions if the total spectrum $g(N)$ (Eq. (6)) is decomposed into a sum of rectangular spectra, and the spot cross section $f(r)$ will be a sum of Bessel functions $(J_1(x)/x)$. Such a subdivision is not very practical as it requires generally too many terms. The gaussian spectrum (Fig. 2, line 6) is much more suitable, although any desired combination could be used. When the measured spectrum is aperiodic, as in Fig. 11, it can be represented

† Derivation presented by the author in *Proceedings of Symposium on Communication Theory and Antenna Design*, January 10, 1957, Boston University (AFCRC-TR-57-105).

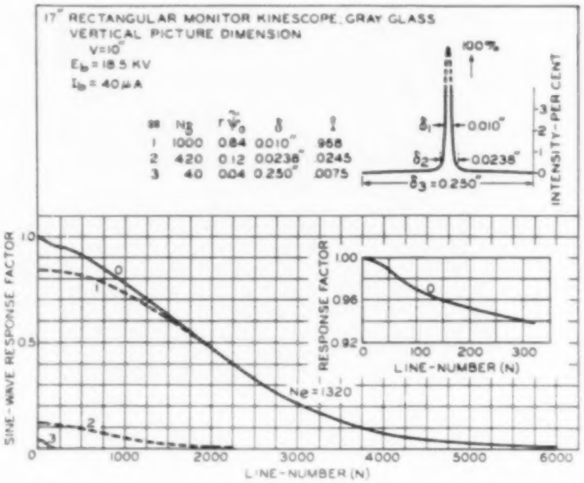

Fig. 11. Sine-wave spectrum (0) of kinescope approximated by the sum of three gaussian curves (1, 2, 3).

entirely by a sum of gaussian curves (three in Fig. 11). The length and relative amplitude of the component spectra are determined graphically by drawing both the measured spectrum as well as a normalized gaussian spectrum

$$g_n(N) = r\tilde{\Psi} = \exp - \left(\frac{\pi N}{8N_\delta}\right)^2 \quad (9)$$

on log-log paper as illustrated in Figs. 12 and 13. The scale factors of the partial spectra are found by placing the kinescope spectrum drawing (Fig. 12) over the gaussian spectrum (Fig. 13) and shifting its coordinates until its "tail"-section matches the gaussian curve, furnishing the width index line-number $N\delta_1 = 1000$ and the amplitude factor $a_1 = r\tilde{\Psi}_{0(1)} = 0.84$ for the example. After subtraction of this component spectrum from the kinescope spectrum, the process is repeated as often as necessary, to obtain the amplitude factors $(r\tilde{\Psi}_{0(n)})$ and index line-numbers $(N\delta_n)$ of the remaining spectrum components as shown in Fig. 12. The response factors at zero line-number $a_n = r\tilde{\Psi}_{0(n)}$ indicate the total flux contribution to the *area* of the line-image cross section or to the *volume* of the point-image.

The line-image cross section $T = F(X)$ *of the kinescope* (Eq. (7)) is the sum of component spatial spectrum transforms which, according to Fig. 2, are also gaussian curves:

$$T = F(X) = c \sum_{1}^{n} T_n, \text{ where}$$

$$T_n = F_n(X) = a_{(n)} \frac{N_{\delta n}}{N_{\delta 1}} \exp -(4N_\delta x)^2 \quad (10)$$

The point-image or spot-cross-section $\tau = f(r)$ is given by the sum

$$\tau = f(r) = c \sum_{1}^{n} \tau_n, \text{ where}$$

$$\tau_n = f_n(r) = a_{(n)} \left(\frac{N_{\delta n}}{N_{\delta 1}}\right)^2 \exp -(4N_\delta r)^2 \quad (11)$$

The reciprocal spread factor $(N_{\delta n}/N_{\delta 1}) = \delta_1/\delta_n \leq 1$ in these equations expresses the known fact that the line-image transmittance T decreases in proportion to its width (δ) because its area remains constant, while the constant volume of the point-image requires that a change of diameter (δ) decreases transmittance values (τ) by the square of the spread factor. The constants c in the summation are arbitrary and can be given values to normalize the total transmittances (T or τ) to equal unity at $x = 0$ or $r = 0$. The distance scales (x or r) are obtained in the units in which the line-number N is expressed, i.e. when N is given in lines per inch, x and r are obtained in inches.

7. Equivalent Passband (N_e) and Spot Size

The equivalent passband of a kinescope or projector is obtained by graphic integration of its power spectrum

$$N_e = \int_0^\infty r\tilde{\Psi}^2 dN \quad (12)$$

(area under the squared sine-wave response characteristic). It has been proposed by the author as a measure of image quality[2] and is by definition a "noise" - equivalent passband, which means that an equivalent rectangular spectrum extending to the line-number N_e contains the same total sine-wave power as the actual spectrum. The equivalent two-dimensional "spot" or point-image of constant intensity has a base area $a = 1/N_e^2$. The diameter δ_e of an equivalent round spot of uniform intensity is given by $\delta_0 = 1.08/N_e$ (for derivation see Ref. 2). The diameter of an equivalent cos² spot is given by

$$\delta_{\cos} = 1.59/N_e \quad (13)$$

and the diameter of the equivalent gaussian spot is

$$\delta_g = 4r_0 = 1.6/N_e \quad (14)$$

where r_0 is the radius at which the relative intensity is $1/e$.

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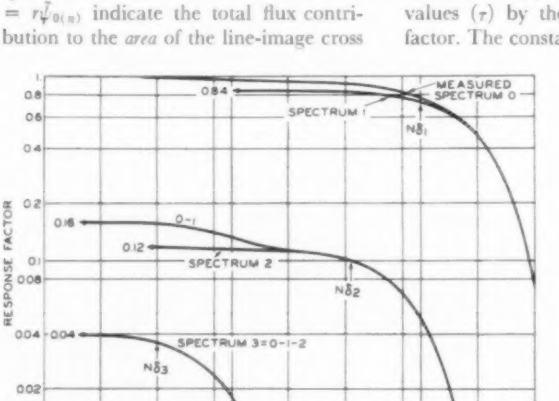

Fig. 12. Graphic method for determining the component spectra of a measured complex frequency spectrum (cf. Fig. 10).

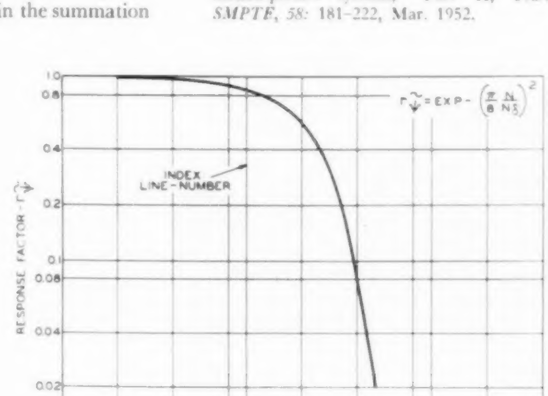

Fig. 13. Normalized gaussian spectrum.

Color Exposure for High-Speed Photography of Some Self-Luminous Events

By K. H. LOHSE

Many problems encountered in high-speed photography of erratic self-luminous events, such as fires, flames, liquid metals and furnace interiors, can be overcome with lens attachments. A new approach to exposure calculation, using computed speed-characteristic curves of cameras, is explained and examples given.

THE HIGH-SPEED PHOTOGRAPHY of some self-luminous events such as fires, flames, liquid metals and slags, as studied in metallurgical research, is complicated by a number of variable factors affecting the exposure. Table I shows typical temperatures and color-temperatures for some such events in metallurgical furnaces.

Scene Brightness

The average scene brightness of such self-luminous events is highly erratic. The brightness in the combustion zone of a normal working blast furnace may range from 25 to 450 ft-c. It may vary as much as 200 ft-c within 1 minute.[1] Some of these brightness changes are due to physical conditions and can be predicted; however, even within a predicted "constant" period, sudden changes may occur. Other furnaces may have a narrower range but may also show spontaneous changes. It is of utmost importance that the scene brightness be measured immediately preceding the activating of the camera. The closer the actual exposure follows the reading and setting, the more accurate an exposure can be expected.

Presented on April 22, 1958, at the Society's Convention in Los Angeles by K. H. Lohse, Edgar C. Bain Laboratory for Fundamental Research, U.S. Steel Corp., Monroeville, Pa.
(This paper was received on April 16, 1958.)

In the past self-luminous events have been filmed according to the following practice. According to a manufacturer's speed-characteristic curves, the film speed at a given applied voltage was considered *constant.* A special light meter, such as the Weston Model 603, was hand-held to measure the brightness of the event. Then the lens was set and the film exposed according to a trial and error method.[1] This method yielded many films which were greatly over- or under-exposed. Obtaining acceptable film depended largely on the good luck and experience of the cameraman.

In our work the projected films indicate to the audience the relative temperature of portions of the event.[2] A scientist who has viewed many films will notice a difference of $\frac{1}{3}$ *f*-stop. A particle, which is of a lighter shade of yellow, is interpreted as being hotter. A slight change in exposure would transmit a wrong impression. Our objective is to expose films within a $\frac{1}{3}$ *f*-stop. It is hoped that in the future the method will be further improved to include actual temperature measurement.

What Is Correct Exposure?

In general photography, the exposure depends mainly on the type of subject and the pictorial effect desired by the photographer. In high-speed photography of self-luminous events correct exposure can be clearly defined. Correct exposure would include as much of the scene brightness as the latitude of the film permitted. If one part of the scene is of greater interest, the correct exposure would be adjusted accordingly.

Table I. Typical Temperatures and Corresponding Color Temperatures Within Metallurgical Furnaces

Event	Temperature F	Color Temperature K
Blast furnace		
Combustion zone	3400–3600	2150–2250
Open hearth furnace		
Top of Slag		
Flame on	2800–3000	1820–1920
Flame off	2750–2950	1775–1875
Gas-oxygen furnace		
Boiling stage	2700–2900	1750–1865
Metal particles	3200	2050

Accurate exposure is defined for the purposes of this discussion as the correct exposure which is color compensated by means of filtration to match the average color temperature of the event with that of the film emulsion. Furthermore, a correction is required according to the reciprocity effect.

Camera Characteristics

Each individual camera has its own performance pattern. For high-speed work on the self-luminous events described in this paper, two types of 16mm cameras were used:

(1) The Eastman High-Speed Camera, Type III, with taking rate of 650

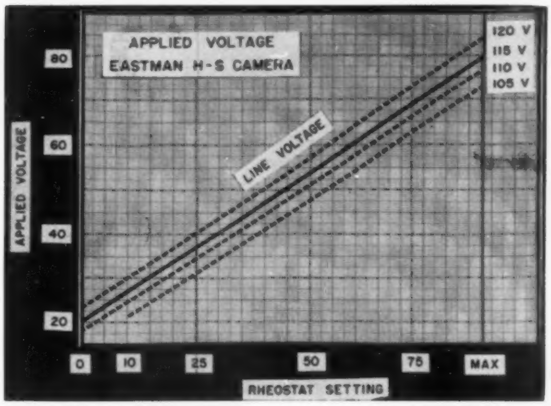

Fig. 1. Relationship between applied voltage, line voltage and rheostat setting of Eastman high-speed camera.

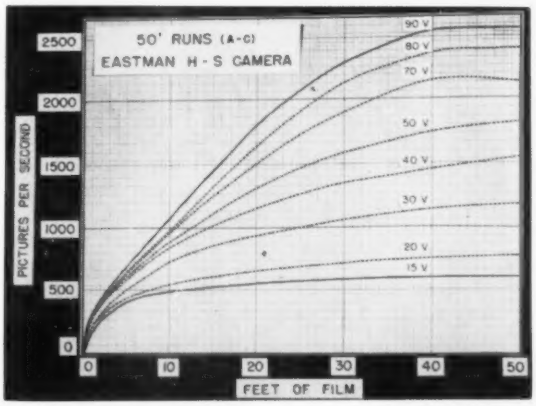

Fig. 2. Speed characteristic curves for 50-ft runs of Eastman camera at various applied voltages.

Fig. 12. Graphic method for determining the component spectra of a measured complex frequency spectrum (cf. Fig. 10).

Fig. 13. Normalized gaussian spectrum.

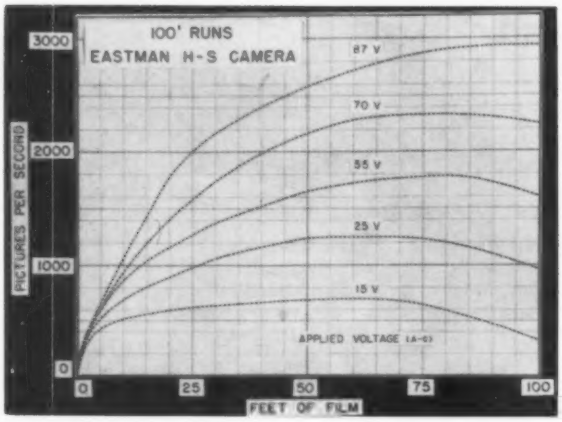

Fig. 3. Speed characteristic curves for 100-ft runs of Eastman camera at various applied voltages.

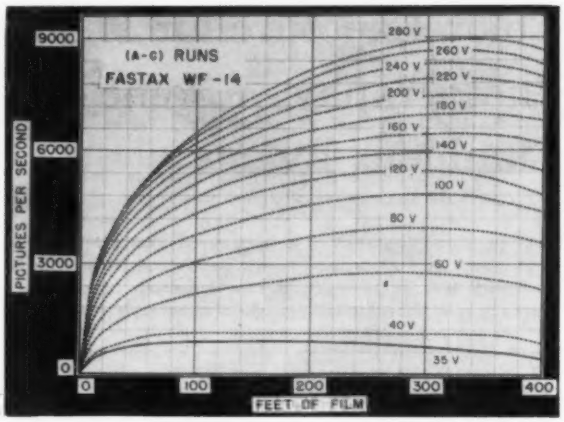

Fig. 4. Speed characteristic curves for 400-ft runs of Fastax WF-14 camera at various applied a-c voltages.

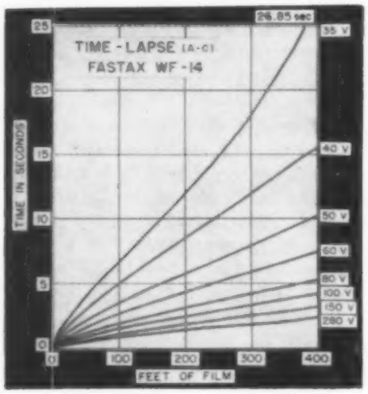

Fig. 5. Time-lapse curves for 400-ft runs of Fastax WF-14 camera at various applied a-c voltages.

to 2500 pictures/sec and 100-ft film capacity, operating on a-c.

(2) The Wollensak Fastax Camera, WF-14, with taking rates of 100 to 1100 pictures/sec on d-c operation and 800 to 8000 pictures/sec on a-c operation with 400-ft film capacity.

Frequently we find in high-speed photographic literature a statement such as "the event was photographed at 2000 pictures/sec. . ." Such a statement is, in a strict sense, meaningless unless further explanation is given. All characteristic curves of popular high-speed motion-picture cameras indicate that a constant speed is reached only during a few feet of a run. There are three possibilities of misunderstanding the above statement. The 2000 pictures/sec could either be the terminal speed, or the top speed, or the average speed of a run.

Characteristic Curves

In order to evaluate a given high-speed technique or event in respect to exposure determination, it is highly recommended that the picture frequency be reported according to the following system. Based on the performance curve of a camera, at a given applied voltage that part of the curve is determined which is within $\frac{1}{3}$ *f*-stop, neglecting the acceleration and, if indicated, the deceleration portions. The average speed of the portion within $\frac{1}{3}$ *f*-stop is reported. Using this method would be a step forward in the exchange of ideas concerning the improvement of high-speed exposures.

Since the individual performance of a camera is of utmost importance insofar as correct exposure is concerned, the performance curves of the cameras previously named were plotted according to test timing films for some typical applied voltages. All intermediate curves were computed in increments of 5 v applied voltage. The corresponding time-lapse curves were obtained by the same method. Some rather unexpected performance and time-lapse curves resulted.

Figure 1 shows conversion of line voltage and rheostat setting to applied voltage for the Eastman camera. Figures

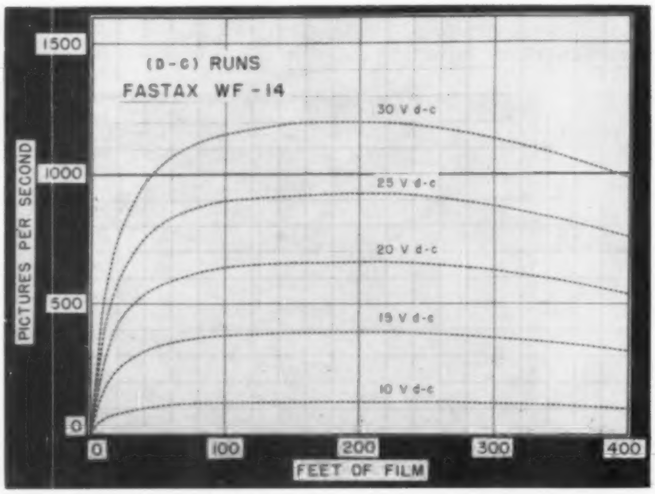

Fig. 6. Speed characteristic curves for 400-ft runs of Fastax WF-14 camera at various applied d-c voltages.

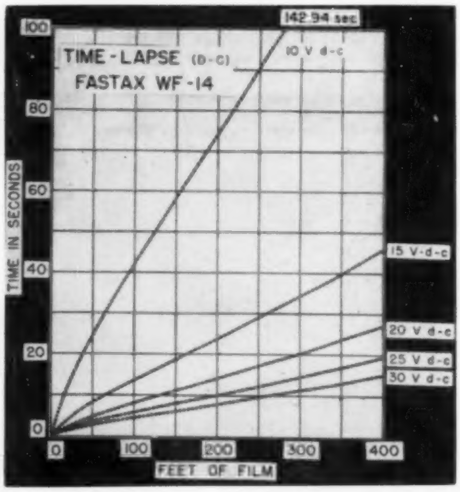

Fig. 7. Time-lapse curves for 400-ft runs of Fastax WF-14 camera at various applied d-c voltages.

Fig. 1. Relationship between applied voltage, line voltage and rheostat setting of Eastman high-speed camera.

Fig. 2. Speed characteristic curves for 50-ft runs of Eastman camera at various applied voltages.

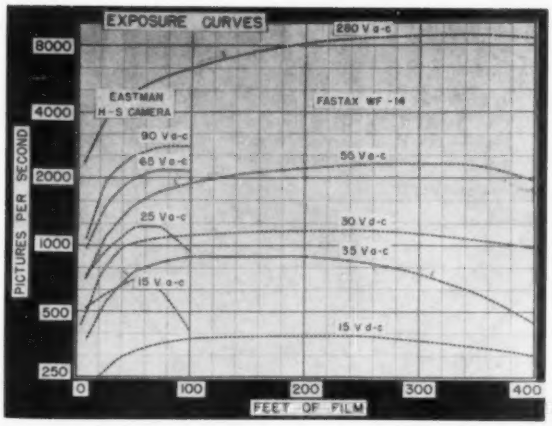

Fig. 8. Exposure curves for Eastman and Fastax WF-14 cameras.

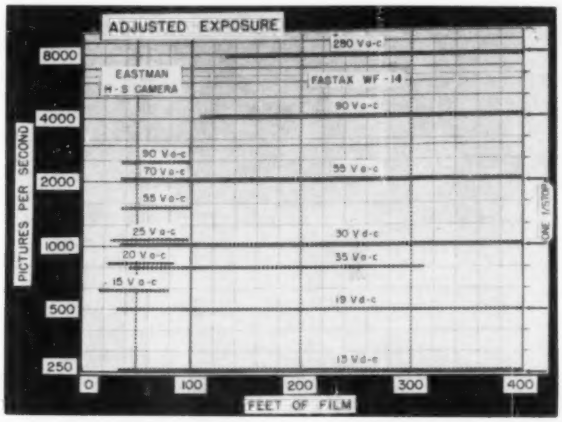

Fig. 9. Simplified presentation of exposure curves for Eastman and Fastax WF-14 cameras.

2 and 3 show performance curves for the Eastman camera for 50-ft and 100-ft runs, respectively. Figures 4–7 show performance curves for the Fastax WF-14 for 400-ft runs a-c, for a-c time-lapse, for 400-ft runs d-c, and for d-c time-lapse, in that order.

The ordinates of all the speed curves are pictures/sec and footage and scales are linear.

Characteristic Exposure-Time Curves

The speed-characteristic curves and the time-lapse curves for high-speed cameras, as they are generally presented by the manufacturers, are very useful for selection of camera speed in regard to motion of subject, timing of the event, and event-camera synchronization; however, for accurate exposure calculations it is more desirable to rearrange the pictures/sec scale to be linear in *f*-stops. Within the range of interest, 250–8000 pictures/sec, the relationship between picture/sec and *f*-stop is logarithmic (Fig. 8). This shows the method of calculating the number of feet of film within $\frac{1}{3}$ *f*-stop at a given applied voltage. As the camera speed increases the unusable acceleration period becomes longer. For lower speed a-c runs the end of the film becomes unusable because of deceleration; as a result, at intermediate speeds the longest portion is within $\frac{1}{3}$ *f*-stop. The Eastman camera yields from 60 to 70 ft of useful film at all operational speeds. The Fastax WF-14 camera yields for 400 ft a-c runs from 270 to 315 ft of film within $\frac{1}{3}$ *f*-stop. Since the d-c performance of the WF-14 camera shows straighter curves, it is better to use direct current for runs of 1100 pictures/sec and lower. Throughout the d-c performance range of this camera, 350 to 365 ft of film are within $\frac{1}{3}$ *f*-stop. As explained later, there are ways by which an experienced camera operator can increase the length of the useful portion.

Figure 9 is a simplified presentation of exposure curves. It gives the useful portion of the film footage for a few typical rates of operation. By interpolation it is possible to estimate the useful footage at other speeds. For convenience the speed given is the average throughout the useful portion. Figure 9 also gives the applied voltage for each of the given speeds. The total range of *f*-stops is 2 for the Eastman camera and 5 for the Fastax camera. This presentation permits the selection of proper exposures for various camera speeds, if the basic exposure is known.

Brightness Measurements

The rapidly fluctuating scene brightness of self-luminous events requires a wide range of *f*-stops. The time-lag between light-meter reading and taking of the picture has been too great when the conventional method was used. To shorten this time-lag the attachment shown in Fig. 10 was designed. The photoelectric cell of a light meter is held in front of the lens in the optical path. The ammeter is mounted at the rear of the camera (Fig. 11). When the ammeter shows the preselected brightness, the cameraman depresses a cable release, thus dropping the photoelectric cell out of the optical path, and activates the camera. In practice the brightness of

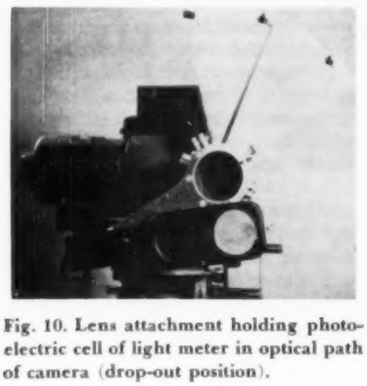

Fig. 10. Lens attachment holding photoelectric cell of light meter in optical path of camera (drop-out position).

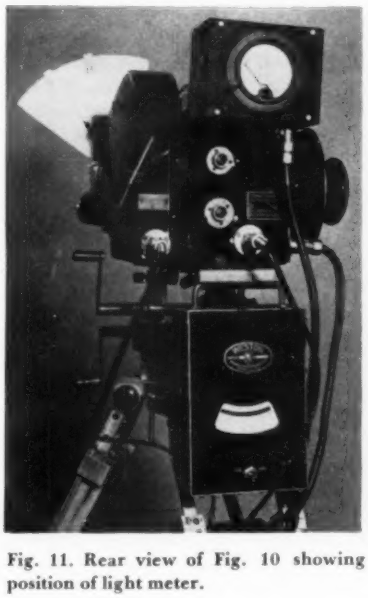

Fig. 11. Rear view of Fig. 10 showing position of light meter.

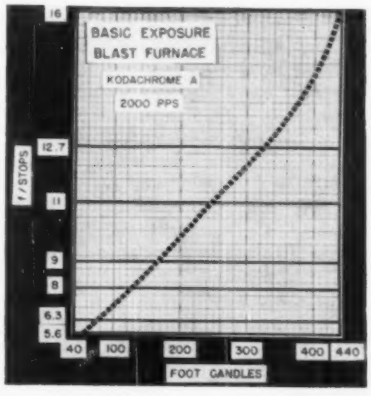

Fig. 12. Relationship of basic exposure of blast furnace combustion zone versus scene brightness in ft-c, using a 4-in. lens.

Fig. 6. Speed characteristic curves for 400-ft runs of Fastax WF-14 camera at various applied d-c voltages.

Fig. 7. Time-lapse curves for 400-ft runs of Fastax WF-14 camera at various applied d-c voltages.

Fig. 13. Lens attachment permitting accurate diaphragm setting.

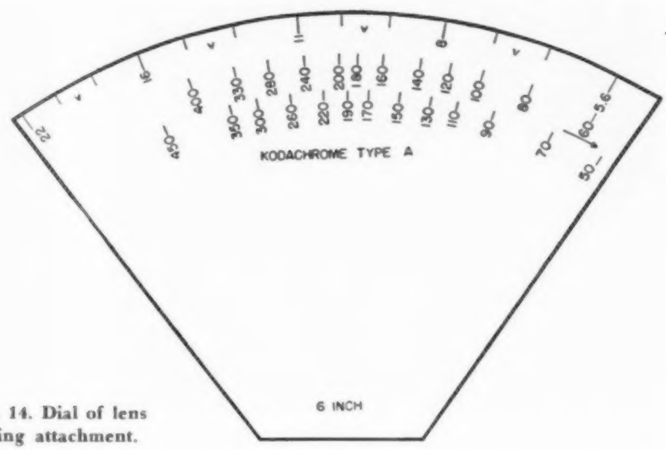

Fig. 14. Dial of lens setting attachment.

Fig. 15. Adjustable stops of lens setting dial.

the event will remain fairly constant during the seconds of the high-speed exposure.

Basic Exposure for an Event

The analysis of about 100 high-speed motion pictures taken of the combustion zone of blast furnaces yielded curves representing good exposure (Fig. 12). The following method of analysis was employed. The camera speed was determined every 5 ft of film by using a slide rule as described by K. W. Maier.[3] The best exposed frame was selected by means of visual and densitometric inspection. Since the *f*-stop and light meter reading had been recorded at the time the film was exposed, accurate data were known for the selected frames. Finally, the results were calculated for exposures corresponding to 2000 pictures/sec and plotted according to *f*-stops vs. foot-candles. Lenses of various focal lengths require slightly different *f*-stops. The actual light transmission of a lens, rather than the theoretical diaphragm opening, has to be considered. These practical curves were used as the starting point for more precise test exposures. After these test exposures were made the curves were slightly modified. The result for a 4-in. lens is shown in Fig. 12.

The reason for various self-luminous events having different basic exposure may depend on a number of factors, such as size of furnace, overall temperature, atmosphere of furnace, chemical composition of subject, etc. Based on an estimated exposure, a test film is exposed. An experienced camera operator can estimate the exposure with fair accuracy. In some instances, where this accuracy cannot be expected, a bracketed test exposure of two or more films is indicated. For each test film the characteristic camera curve is plotted, and the best exposure is selected by frame-to-frame inspection. This information is used for the lens-setting dial.

Lens Setting Attachment

Practical tests showed that the *f*-stop setting is critical within $\frac{1}{3}$ *f*-stop. Most camera lenses have the higher *f*-stops so closely spaced that it is practically impossible to adjust accurately for $\frac{1}{3}$ *f*-stop under taking conditions. In order to permit a fast and accurate lens setting, a lens attachment (Fig. 13) was designed for each lens used in our high-speed work. The attachment consists of an extended indicator needle attached to the diaphragm setting ring, and a plate mounted on the stationary lens body. An interchangeable lens setting dial printed on photosensitized metal is fastened to the plate. A lens setting dial is based on

(1) type of event — basic exposure,
(2) brightness in foot-candles,
(3) type of lens — focal length and mechanical diaphragm construction,
(4) type of film, and
(5) taking rate in pictures/sec.

Figure 14 shows such a dial. This one is designed for the combustion zone of a blast furnace, Eastman High-Speed Camera Type III with 6-in. Ektanon lens, Kodachrome Type A film, and yields correct exposure at 2000 pictures/sec.

At the preselected exposure setting, a stop for the indicator needle is attached. A second stop is clamped on the dial at a smaller lens opening, depending on the performance curve of the camera. A skilled operator can manually compensate for the curve during the run, thus obtaining more footage of film exposed within $\frac{1}{3}$ *f*-stop (Fig. 15). It would seem practicable to design an automatic diaphragm control which would respond to both brightness and speed variations.

Exposure- and Color-Correction

The overall temperature of a self-luminous event can be measured with an optical pyrometer. The obtained degrees Fahrenheit are translated into degrees Kelvin. Using decamired values, a practical color compensation can be obtained. 1,000,000 is divided by the measured degrees Kelvin. The result is divided by 10. The decamired value for the color film emulsion is similarly determined and is subtracted from the decamired value of the event. The result is the decamired value for the filter, which compensates for the difference in color temperature between the event and the sensitivity of the film.

Another approach to color compensation is a test method based on color-densitometric analysis of a test film, which leads to CC-type filters. Gelatin filters, used in general photography, cannot withstand the heat to which the equipment is exposed. Coated glass filters are preferable. The exposure increase required for the filter selected is added to the basic exposure of the event.

Occasionally the subject of interest may not be the general overall condition. Some particles, for instance, may considerably differ in color tempera-

Fig. 10. Lens attachment holding photoelectric cell of light meter in optical path of camera (drop-out position).

Fig. 11. Rear view of Fig. 10 showing position of light meter.

Fig. 12. Relationship of basic exposure of blast furnace combustion zone versus scene brightness in ft-c, using a 4-in. lens.

Fig. 16. Location of camera at a blast furnace.

ture from the average scene. In such cases, practical tests determine the deviation.

Some cameras require some color compensation for the type of glass used in the rotating prism; however, this is a constant correction.

For this type of high-speed photography we have used Kodachrome Type A and Anscochrome Tungsten Type films. For a larger depth of field, the Anscochrome was used. For work with accurate exposure and color balance the expected speed-gain of the Anscochrome film was partially lost, due to necessary additional filtration. The densitometric analysis of comparable high-speed films taken with Kodachrome and with Anscochrome has shown that the short-exposure reciprocity effect within the emulsion layers varied more in the Anscochrome film than in the Kodachrome film, necessitating correction for exposures of 2000 pictures/sec and up. For Anscochrome used at 2000 pictures/sec a correction of CC-05M or CC-10M was needed. The filter required $\frac{1}{3}$ *f*-stop increase. The neutral-density reciprocity effect required another $\frac{1}{3}$ *f*-stop increase. The effective speed gained by using Anscochrome instead of Kodachrome film was thus only $\frac{1}{3}$ *f*-stop.

The reciprocity law failure characteristics of the film used must be known and considered. According to J. H. and J. W. Waddell[4] the time of exposure (E), expressed in terms of pictures per second, is approximately $E = \frac{1}{6} \times 1$/pictures/sec for the Fastax camera, and $E = \frac{1}{5} \times 1$/pictures/sec for the Eastman camera. In respect to reciprocity law failure we must consider as ranges of actual exposure time in seconds the following:

1/1500 – 1/6000 sec for Fastax d-c runs;
1/4800 – 1/48000 sec for Fastax a-c runs; and
1/3000 – 1/12500 sec for Eastman a-c runs.

The reciprocity failure characteristics of the new Super Anscochrome film, as reported by A. F. Gifford and F. H. Gerhardt,[5] promise an improvement; however, we have not yet had the opportunity to test and evaluate this film.

Camera Technique

Many furnace interiors have no stationary objects which can be used to focus the camera visually. It is common practice to determine the film to subject distance and focusing range, using blueprints of the furnace. The lens calibration should be checked. The immediate vicinity of self-luminous events requires that photographers wear appropriate safety clothing. Cameras became so hot in some taking positions that the operator requires asbestos gloves. The cameras can be protected from excessive heat with aluminized asbestos covers, leaving an opening for the lenses. No film was lost due to exposure to excessive heat because the film was left in the camera no longer than absolutely necessary. Figure 16 shows the camera position for blast furnace photography.

Summary

For accurate color exposure in high-speed photography of self-luminous subjects many variable factors must be considered. Two lens attachments, a light-meter holder and a lens setting dial which permit fast and precise camera adjustments, are required. The basic exposure for a given self-luminous event must be modified according to film type, reciprocity law failure and camera speed. Characteristic performance curves for the Eastman High-Speed Camera Type III and for the Fastax Camera Model WF-14 have been shown. A practical method of reporting high-speed exposures which is based on adjusted exposure curves has been suggested. These curves are also useful for a rapid determination of exposures if the camera speed is changed.

(At the Convention numerous examples of films of self-luminous events were projected.)

Acknowledgment

The author gratefully acknowledges the help of many members of the Edgar C. Bain Laboratory for Fundamental Research, especially the work of R. W. Whitmore, who computed the characteristic curves and time-lapse curves. Thanks are also due to Q. Henderson, who supervised the construction of the various lens attachments. The help and advice of B. M. Larsen and L. O. Sordahl are greatly appreciated and the author also wishes to extend thanks to the members of this Laboratory's Photographic Section who contributed their efforts to the field tests and the data reduction. J. B. Wagstaff's constructive criticism is appreciated.

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Discussion

Anon: How do you photograph metal coming out of the furnace into the ladle?

Mr. Lohse: The high-speed cameras equipped with telephoto lenses are placed on a platform located on the casting-floor across from the furnace. Generally that would be approximately 30 ft away from the opening of the furnace.

Lincoln Endelman (Convair Astronautics): Did you ever attempt to photograph this through a Polaroid filter; and if so, with what results?

Mr. Lohse: Yes, in making flame studies. A Polaroid filter was found very useful. Some of the detail of flames seemed to show up better when such a filter was used. There was a sharper delineation between certain portions within large flames.

Mr. Endelman: Did you try spectrographic or infrared film as well as color film?

Mr. Lohse: Infrared film has been used, but we don't think we have as yet attained sufficient accuracy in the film processing technique necessary to measure temperature photographically. Further experiments are desirable. Right now our error is rather high and to obtain accurate exposure is still very difficult under practical shooting conditions.

Mr. Endelman: Did you have any special determination other than exposure for the frames/sec which you used?

Mr. Lohse: Yes, it has been found that 2000 pictures/sec as far as tuyere- and flame-photography are concerned is sufficient to stop the action and fast enough to see overall action.

Mr. Endelman: Would speeds faster than 2000 pictures/sec offer any particular information regarding the movement of the particles?

Mr. Lohse: Only if very special particles are considered, for instance small and fast particles; in such instance we have taken pictures at 8000 pictures/sec and it might be useful to have even faster framing rates but the general overall metallurgical condition in furnaces can be studied quite well at 2000 pictures/sec. There are other fields which are not covered by this paper, such as welding arcs, where we definitely need higher framing rate. Strictly speaking, this is not a self-luminous event but is better described as a self-luminous plus illuminated event.

Mr. Endelman: Did you build special boxes to protect the equipment?

Mr. Lohse: We have aluminum-covered asbestos covers for the cameras but the lenses are protected only in very rare instances; for example, when close to the furnace, we use some silica glass in front of the camera.

Mr. Endelman: What was the ambient temperature of the camera?

Mr. Lohse: The cameras may get so hot that we have to use asbestos gloves to load them and handle them and we keep the film in the camera for as short a time as possible. We have not measured the actual temperature of the cameras. It depends on how long they are standing in the furnace position.

Practical Film Cleaning for Safety and Effectiveness

By D. W. FASSETT, F. J. KOLB, JR., and E. M. WEIGEL

Because the various kinds of dirt that can accumulate on motion-picture film degrade the image quality of negatives and positives, film cleaning has always been an important operation. This paper reviews the problems of cleaning current color and black-and-white films, and classifies possible cleaning solvents on the basis of inertness to film, hazards to personnel, risk of fire, physical properties and cleaning efficiency. No solvent meets all requirements but commercial operation is possible with carbon tetrachloride, Freon-113 and hexane. Methyl chloroform, now commercially available, has some advantages over each of these. As a matter of fact, practical cleaning can also be accomplished with water. The importance of good technique in film cleaning is emphasized.

CONTENTS

I. THE FILM-CLEANING OPERATION

High acceptance standards set for professional print quality make it essential that motion-picture film be cleaned periodically. The actual frequency of cleaning depends, to a large degree, on the type of film (whether positive or negative), the subject matter, the use it receives, and the standards for cleanliness and print quality maintained by the responsible individuals.

The objective is to remove from both sides of the film all foreign material that might detract from the final quality, and at the same time to introduce as little damage to the film as possible during the cleaning operation.

Negatives and intermediate films usually pick up a surface accumulation of foreign matter during cutting, editing and printing operations. This dirt becomes even more obvious on the final print because the high contrast of the print film increases the contrast of the dirt image. In a carefully operated laboratory the principal dirt is a surface accumulation of dry dusts and lint. To remove this, the negative should be cleaned before the first print is made, and also periodically during the printing runs. This may be done after each print, after 5 to 50 prints or after longer intervals depending upon the laboratory.

The amount of dirt that can be allowed to accumulate on a print is usually greater than can be tolerated on a negative.

II. FILM-CLEANING SOLVENT PERFORMANCE

Although there are occasions when film can be cleaned successfully with an air blast, a dry plush, or related technique, it is usually more convenient to use a suitable solvent to aid in this operation.

Removal of Surface-Accumulated Foreign Matter

Film which needs cleaning may carry a variety of dirts such as processing sludge, lubricating oils, adhesive from tape, wax from crayons, fingerprints, lint, etc., or it may carry particles scraped from the film itself by the friction of gates, guides, etc., in the film-handling equipment. Oils and similar materials must be dissolved for removal, since a nonsolvent will merely spread them over the film surface in an uneven pattern leaving mottled areas that will print through or project. Nonsoluble dirts must be loosened from the film surface and floated or wiped away in a manner that prevents film abrasion.

Inertness to Film Components

Film cleaning is intended to act only on foreign substances, and to improve the pictorial or performance quality of the film by their removal. Therefore, an ideal cleaning solvent must be inert not only to the silver images of black-and-white film, but also to the toned images and dye images resulting from modern photographic color processes. Furthermore, the cleaning must have negligible action upon the plastic film base supporting the emulsion and upon the physical properties of the emulsion itself.

There are relatively few solvents active enough to dissolve film base; however, many solvents whose activity falls far short of dissolving the base can still be absorbed in harmful amounts. Film base swollen by solvents may be stretched and distorted, may show the imprints of adjacent convolutions, and may abrade easily. It may also show high rates of dimensional and other undesirable changes as the absorbed solvent gradually leaves.

Presented on October 5, 1955, at the Society's Convention at Lake Placid by D. W. Fassett, F. J. Kolb, Jr., (who read the paper) and E. M. Weigel, Eastman Kodak Co. Kodak Park Works, Bldg. 35, Rochester 4, N.Y.
(This paper was received on April 8, 1958.)

Finally, a cleaning solvent used on negatives intended for contact printing must leave no photographically active residue that could initiate fog growth or desensitization of the positive film during the printing operation.

Freedom From Hazard

Health and safety standards demand that any proposed film-cleaning methods and materials be viewed critically for any possible hazards. Physiological dangers to personnel through ingestion, inhalation or physical contact with solvents and their vapors are criteria for determining not only whether a given material is suited for use but also the type and extent of equipment needed to adequately safeguard personnel.

Hazards associated with low-flash-point solvents are also primary considerations. The lower the flash point or the lower the maximum allowable concentration (MAC), the more elaborate the ventilating systems, static eliminators, etc., required. Large laboratories where film cleaning is a major operation may amortize the cost of ventilating equipment out of savings in the purchase of solvent. In laboratories, however, where such cleaning is only a minor operation, the cost of equipment necessary to provide proper ventilation and maintain vapor concentrations within safe limits for the more hazardous solvents may be prohibitively expensive.

Convenience

Custom has established certain techniques for film cleaning designed largely around the use of carbon tetrachloride. As a result, the desirable physical properties of an ideal film-cleaning solvent have been closely related to the properties of carbon tetrachloride. Solvents of quite different properties can be used if the technique of cleaning is altered, but it is usually very difficult to make such changes. The physical operation of cleaning should resemble either hand inspection and rewinding, or the simpler mechanized rewinding operations.

III. REVIEW OF PREVIOUS WORK

From the earliest days of motion pictures, dirt has been a problem and considerable effort has been directed to the cleaning of film. As soon as practical projection light sources became available, motion-picture images were frequently magnified over 200 diameters — and the trend has continued until now magnifications of approximately 2000 diameters are encountered. Continued emphasis has been necessary to keep this dirt sufficiently inobvious so that it does not intrude upon the artistic objectives of the picture.

Emphasis has shifted, however, as various problems in motion-picture handling have been alleviated, and as standards have changed. Film cleaning was discussed and described in detail 20 to 30 years ago,[14,17] and much of this technology is still applicable. It should be pointed out, however, that there is no longer a need for major concern over water-spot removal and correction of film brittleness. Furthermore, our knowledge of the physiologic effects of solvent vapors has increased tremendously so that more adequate precautions in solvent handling can now be provided.

Water-Spot Removal: After the aqueous processing of film, surface water, if not completely removed, will leave a visible whitish pattern on the film surface as the dissolved salts from the water are left in varying deposits. Cleaning solvents containing small amounts of water were necessary to dissolve these mineral residues, and an extensive study was reported by Crabtree and Carlton.[9,14]

Modern processing equipment employing adequate compressed-air or vacuum squeegees has made water-spot removal an obsolete art.

Solvent Cleaning: The problem of solvent cleaning was quite adequately described by Crabtree and Carlton[9] in 1927. At that time, however, the available solvents that could be considered seriously were limited to the following:

Dichloroethylene	Tetrachloroethylene
Trichloroethylene	Dichloroethane
Benzene	Carbon tetrachloride

As these materials were evaluated 30 years ago, carbon tetrachloride was preferred, both for cleaning processed negative and print films and for removing oil from unprocessed raw stock.[12] At that time, however, it was necessary to maintain careful control over the purity of commercial carbon tetrachloride, testing for the presence of sulfur chloride, free acid, water, and products of hydrolysis and photolysis.

Hazards to Personnel: One very significant advance during the past 30 years is a much better understanding of the effects of solvent vapors upon human beings, made possible by the accelerated research in medicine and physiology, and the development of occupational medicine which in turn led to the publication of many experimental and clinical reports on the hazardous properties of certain solvents. An important consequence has been the growing realization that materials such as carbon tetrachloride and benzene are in fact hazardous substances which require a very high degree of industrial hygiene and medical control for their safe use.[1-3]

The most obvious advances in film cleaning during recent years have been initiated by the search for solvents less dangerous than carbon tetrachloride, and by the developments in the technology of film cleaning that more effectively keep harmful vapors away from personnel.

Standards of Cleanliness: Finally, it should be pointed out that the standards for allowable dirt on motion-picture film have steadily tightened through the years. Every development of improved films, optics, equipment design, etc., that has produced improvements in resolution, graininess, acutance, tone and color reproduction, etc., has at the same time made dirt more visible and has reduced the "thresholds of visibility" for number of defects, size of particles, contrast of defects, etc. This means a constant reappraisal of the efficiency of film cleaning — and there is every indication that this need will continue indefinitely.

IV. CURRENT FILM CLEANING

Film cleaning techniques at the present time are limited to the use of: *dry plush, air blasts* and *solvents*. The choice of technique is dependent upon the nature of the film being cleaned and of the dirt carried by the film: both dry plush and air blasts are primarily limited to the cleaning of negatives during the printing cycle in a motion-picture film laboratory for the removal of "dusts" whose adhesion to the film is low; solvent cleaning is required for more thorough cleansing.

Dry Fabrics

The potential hazards associated with the use of a dry fabric for cleaning are great, and the limitations on efficiency are large; therefore, this technique is successfully employed only in a few motion-picture film laboratories under conditions where nothing but dry surface dirt is to be removed. The important considerations are (1) nature of the dirt; (2) softness and structure of the cloth; (3) removal of abrasive material; and (4) accumulation of static electrical charges.

During laboratory handling of film a certain amount of room dust and dirt settles out on, and is attracted to, the film even from ventilated and dirt-controlled areas. Clothing, gloves and cleaning fabrics produce lint while additional dust appears as particles scraped from the film by edge guides, gate rails, sprocket teeth, etc. These can be removed effectively by the proper use of dry plush. On the other hand, fingerprints, tape adhesives, lubricating oils, editing marks, and similar materials, adhere more tenaciously and are not removed by the purely mechanical action of a dry fabric.

Since many of the hard-surfaced textiles will themselves scratch film emulsion and support, the number of tolerable fabrics is limited. Softer textured materials including those with pile or

nap are essential, and furthermore have the advantage of holding the dirt within their structure, thus taking it out of contact with the film surface. In the case of hard, gritty particles this entrainment in depth can prevent, or at least minimize, film abrasion. The pile fabrics are especially good for such cleaning. These are at their maximum efficiency when used on semiautomatic equipment where a vacuum nozzle continually cleans the plush.

Rubbing a dry cloth against film is an excellent method for building up high electrostatic charges which might, in themselves, defeat the cleaning operation. Highly charged film will attract dust particles from the air and from neighboring work surfaces, so that conceivably the film might be dirtier after cleaning than before. The use of dry plush, therefore is practical only in the motion-picture laboratory where air-conditioning maintains relative humidities of 50 to 65%. Since the film itself has or soon acquires a moisture content approximately in equilibrium with the air[6] (because it is unwound and freely exposed to the air in the course of normal operations), there is a consequent increase in electrical conductivity of the film emulsion. This aids in dissipating accumulating charges, and in combination with equipment designed for static control helps to limit electrification. Dry-plush cleaning is definitely not recommended for low-humidity areas or for workrooms with uncontrolled humidity.

Dry-fabric cleaning, therefore, fills an important need in a very special application, and with care can be completely successful in its limited objectives. It does not have general applicability.

Air Blasts

For the same situations in which dry-fabric cleaning is applicable, it is alternatively possible to use controlled high-velocity air. In this case, the momentum of the air stream impinging upon the film supplies the energy for loosening and removing dust particles. The necessary pressure drop to produce high-velocity jets can be obtained by supplying air under pressure, or by exhausting air under vacuum, or by a combination of the two.

Hazards to the film in air-blast cleaning are somewhat different from those in dry-fabric cleaning, but by no means negligible. The air used must be clean, not only to avoid depositing its dirt upon the film but also to avoid scratching. The use of high-velocity, airborne grit for sand-blasting operations is ample evidence of the damage potential. Airborne oil droplets (so difficult to avoid in air from most compressor systems) not only will collect upon the film surface to produce mottled areas and help dust particles to adhere, but under some high-velocity conditions can also physically deform the emulsion surface. Finally it must be realized that an air stream moving against a poor conductor of electricity like film can and will generate static charges, so that controlled humidity to maintain adequate moisture content in the film emulsion is essential also in air-blast cleaning.

Of course, it is an obvious requirement that any dirt removed by the air be prevented from redepositing elsewhere on the film. This requires adequate air paths so that the dirt once suspended in the air is removed quickly from the film vicinity to prevent reimpingement as well as to prevent settling onto critical areas as the velocity drops.

Air-blast cleaning also, therefore, fills an important need but has limited objectives and applicability.

Solvent Cleaning

The most versatile film-cleaning procedure is the intelligent application of a suitable solvent to the film. The function of the liquid is fourfold: (1) to dissolve some of the dirt; (2) to loosen and disperse dirt that it does not dissolve; (3) to give mobility to grit in order to minimize scratching; (4) to help discharge the static electrification of film so far as is possible.

Single pure solvents accepted as film cleaners have until recently been limited to two. Carbon tetrachloride has been from the early days of motion pictures the most commonly used film-cleaning solvent. It is generally satisfactory from the standpoint of evaporation; it is a good solvent for grease and oil; it is inert to film, and is noncombustible. Finally it is readily available in sufficient purity at a reasonable price. Actually most film-cleaning operations have been developed to make use of solvents having physical properties very similar to those of carbon tetrachloride. Therefore, it is now almost mandatory that a film cleaner be comparable with carbon tetrachloride in desirable physical properties.

While pure carbon tetrachloride meets practically all of the requirements of a film cleaner, there is a growing general awareness of its health hazard.[20] Its safe use requires very effective engineeering control of vapors, the repeated demonstration by chemical measurement that the concentrations in air are well below any hazardous level, and the repeated medical examination of personnel.[1] These strict requirements have been largely responsible for the current interest in substitute film-cleaning materials.

Probably second in popularity as traditional film cleaners is a small group of aliphatic hydrocarbons resembling hexane. Hydrocarbons are generally good film cleaners, although they tend to be less effective in discharging static electricity than the chlorinated materials. Moreover, they represent a considerable fire hazard because of low flash point. Nevertheless, there has been considerable commercial use of hydrocarbon film cleaners where properly designed ventilating equipment has been installed. In spite of this, the increasing concern of various municipal groups about the hazards to the general public associated with the use of flammable materials in urban communities has resulted in increasingly strict regulations. In many areas, therefore, it has become expensive, inconvenient or nearly impossible to use flammable film cleaners.

Beyond these two solvents there is no generally preferred material, although several have had limited use. Within the last ten years Freon-113* has had limited acceptance because it is not flammable and has a much lower toxicity than carbon tetrachloride. The high cost of this material, however, has greatly limited its applications. Recently, inhibited methyl chloroform has become commercially available (Chlorothene†) and this is one of the solvents discussed in greater detail later in this paper. There have also been some attempts to use other solvents such as isopropyl alcohol but the usefulness of these materials is quite limited.

It is apparent, therefore, that the disadvantages of earlier film-cleaning solvents have increased steadily and that this is a profitable time to reexamine all reasonable substitutes.

Proprietary solvent cleaners generally consist of solvent mixtures and solutions. These answer the need of smaller consumers who want to buy small quantities of a cleaner, and they appeal to larger consumers who want something besides a single solvent. In such a proprietary cleaner it is possible to blend several solvents and to incorporate dissolved solids. Solvent blends — as discussed later — allow modification of physical and chemical properties. Dissolved solids consist primarily of materials for the control of electrification, and of film lubrication. In such a presentation as this it is difficult to consider adequately the numerous proprietary film-cleaning materials, but any particular one can certainly be evaluated against the simple materials here discussed. Such an evaluation will tend to aid both manufacturer and user of these proprietary cleaners.

This paper is concerned primarily with the presentation of data on a large number of potential film-cleaning sol-

* Trade name of E. I. du Pont de Nemours & Co., Kinetic Chem. Div., for 1,1,2 trichloro-1,2,2 trifluoroethane. The Kinetic Chemical Div. has recently announced a change in the trade name for 1,1,2 trichloro-1,2,2 trifluoroethane from Freon-113 to Freon-TF. A similar product is available from the General Chemical Div. of Allied Chemical Corp. under the trade name Genetron-226.

† Trade name of Dow Chemical Co. for inhibited 1,1,1-trichloroethane.

vents. It is concerned also with evaluating the techniques of film cleaning and suggesting an integrated approach to the whole problem.

V. LIMITATIONS ON ACCEPTABLE FILM-CLEANING SOLVENTS

The criteria applied to sort out materials worthy of more critical examination were four important properties: evaporation rate, toxicity, flash point and cost. Limits were chosen by reference to four common solvents applicable to film cleaning but possessing certain deficiencies: carbon tetrachloride, hexane, Freon-113 and water. It was decided that solvents beyond the range of these materials would require too great a departure from established practice to be of general interest.

Evaporation Rate: From the materials which are liquid at room temperature, those possessing an evaporation rate no faster than that of Freon-113 and no slower than that of water have been selected. Although it is entirely practical to design apparatus for handling solvents having a much wider range of evaporation rates, much less complicated equipment is required for use with solvents within these limits. Solvents for hand-cleaning operations are limited to even a narrower range.

The use of materials having a more rapid evaporation rate than Freon-113 results in excessive solvent loss, and sometimes even in moisture condensation because the evaporation of the solvent cools the film below the dew point of the air. Similarly, the use of solvents whose evaporation rate approaches that of water requires excessive drying times by normal convection, and may require the use of a drying cabinet. It was found, however, that cleaning with water (containing a detergent) coupled with impingement drying can be carried out on equipment sufficiently simple and compact to make it practical in many cases.

In this screening operation, therefore, a lower limit was imposed on the vapor pressure of the cleaner of 20 mm mercury at 20 C and an upper limit of 300 mm at 20 C.

Physiological Hazards: The only reasonable objection that can be raised against carbon tetrachloride as a film cleaner is its health hazard. This is reflected in the currently accepted value for the maximum allowable concentrations‡ for carbon tetrachloride vapors in air to be breathed, which is 25 ppm (parts per million), or approximately 0.160 g/cu m. It seemed justifiable, therefore, to eliminate from serious consideration volatile materials with a high degree of toxicity — with MAC's of 25 ppm or less — providing that such concentrations could be reached in the saturated vapor at reasonable temperatures. Other materials were eliminated because of hazardous absorption through the skin or irritant action on the skin.

‡ These concentrations, sometimes abbreviated as MAC, are also referred to as Threshold Limit Values. Where data are available, the values for solvents evaluated in this paper will be taken from the report of the American Conference of Governmental Industrial Hygienists.[8]

Flash Points: Hydrocarbons suitable for film cleaners are classified as hazardous materials on the basis of low flash point. We have selected hexane with its flash point of -15 F as representing the lowest acceptable flash point because except for this limitation it is otherwise desirable. Actually the precautions necessary to keep the vapor concentration below the explosive limit are no more than those required to keep the concentration of carbon tetrachloride below its toxic limit. In suitably designed equipment, therefore, it may be possible to use hydrocarbons with complete safety. Practically, however, the controlling factor will be local fire regulations and many communities will impose limitations much more severe than we have chosen.

Cost: The direct cost of the solvent often makes a small but hardly ever negligible contribution to the cost of film cleaning. Therefore, the availability of Freon-113 — a very satisfactory film cleaner — at a price which prevents it from competing in a great many applications sets a natural limit on maximum cost of a film-cleaning solvent. Inasmuch as the price data are obtained from several different sources representing differences in quantity, packaging, service, etc., it was necessary to use a different price scale within each series. In the range of interest to a commercial motion-picture laboratory, however, the price of Freon-113 is about $0.84 per lb in 10-lb lots (3.09 qt), and $0.64 per lb in 200-lb lots (15.4 gal).

Obviously the cost of a solvent is not an invariable property and changes rapidly with changes in the chemical industry. This one screening criterion, therefore, should be reviewed every several years to keep pace with new solvents that can be expected to become available.

VI. SCREENING OF SOLVENTS

Table I lists a number of solvents that might be considered for film cleaning, and tabulates enough information either to confirm their usefulness or to establish a reason for rejecting them. The solvents listed include those reported to be used as film cleaners, those that have been the subject of inquiry, and those suggested by the preliminary criteria discussed above.

From this group only fourteen meet the following additional requirements for film-cleaning solvents sufficiently well to be of real interest. This smaller group is identified in Table II.

The details of this further screening are of interest in order to describe the methods of evaluation which can be applied to solvents in general and to proprietary mixtures.

(1) Evaporation Rate

Whenever the allotted drying time is restricted and no auxiliary drying aids are provided, rate of evaporation is an important limitation. Only when film-cleaning equipment provides a drying cabinet with circulating heated air does it become a secondary consideration. This restriction alone serves to eliminate many materials. In normal hand cleaning of film on a rewind, for example, the time available for evaporation from the cleaning point to the take-up roll is only in the order of one or two seconds, and there must be complete evaporation of all the solvent applied.

The melting and boiling points of a substance frequently indicate with sufficient accuracy its general suitability from the standpoint of evaporation rate. When available, published vapor pressure data at room temperatures were also utilized for more critical distinction. However, because vapor pressure data are rather limited, empirical evaporation rates for some solvents that were judged sufficiently important were also measured. This was accomplished by placing 0.3 ml of solvent on a watch glass shielded from drafts and noting the time required for evaporation to dryness.

(2) Personnel Hazard

Substances which were known to be highly hazardous were immediately eliminated without further consideration. Also discarded were those materials which had a seriously offensive odor or were known to cause dermatitis.

Considerable literature exists on the industrial toxicology of a few of the remaining solvents. The commercial availability of many others is very recent and their industrial applications have been limited and of short duration. All of these solvents have been considered and rated in the order of their approximate overall hazard in use as film cleaners. In estimating the hazard, we have taken into account both the inherent acute and chronic toxicity of the materials, and also considered to some extent the relative degree of volatility. We have tried to consider both what is known about animal experiments and what is known from human experience with these substances. Obviously there is a great deal more known about some of them such as carbon tetrachloride than about others. Thus, it was possible to divide the solvents in Table II into groups representing

Table I. Solvents Seriously Investigated for Possible Use as Film Cleaners. (Note that many of these proved to be undesirable.)

	Volatility			Flash Point		Effect on Film: Support		Effect on Film: Image		Toxicity				Reason for Rejection
	Boiling Point, °C	Vapor pressure, mm Hg/20°C	Evaporation time, 0.3 ml, min	Open cup, °F	Closed cup, °F	Film base	Tenite core	Silver	Dye	Gen. hazard	MAC ppm	Cost	Odor	(Nos. refer to columns of this table)
Column Nos.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
n-Amyl chloride	108			54		None	None					High	Sweet	1, 12,*
tert-Amyl chloride	86											High		12
Isoamyl chloride	100		23.5			None	None					High	Objectionable	12, 13
Amyl methyl ether	88	≈60										High		12
Benzene	80	77			10	Slight	Slight			High	25	Low	Hydrocarbon	10, 11,†
1-Bromo-2,2-difluoroethane	57											High		12
tert-Butyl acetate	95			100		None	None					High		12
Butyl bromide	102	33		55						Mod.		Mod.		10
n-Butyl chloride	78	80	13.5	20	16	None	V. Sl.	None	None	Mod.		Mod.	Ethereal	—, Table II
tert-Butyl chloride	51	233										High		12
Butyl ethyl ether	91	43		40								Mod.		12
tert-Butyl ethyl ether	68											High		12
Butyl methyl ether	71											High		12
Carbon tetrachloride	77	91	14.7	None	None	None	None	None	None	High	25	Low		10, 11,‡ Table II
Chlorobromomethane	67			None	None	Severe	Severe			Mod.	400	Mod.	Chloroform	6, 7, 10
1-Chloro-2-butene	84											High		12
1-Chloro-2,2-difluoroethane	36											High		12
Cyclohexane	81	80	15.0	40	1.8	None	None	None	None	Low	400	Low	Aromatic	—, Table II
Cyclohexene	83	67		< −20						Low	400	Mod.		4
Cyclopentane	50	272	6.5	< −10	< −10	None	None	None	None	Low		Mod.		—, Table II
Cyclopentene	44	300										High		2, 12
1,1-Dichloro-2,2-difluoroethane	60											High		12
1,2-Dichloropropane	97	42		65	59	Mod.	Severe			Mod.	75	Low	Sweet	6, 7
1,2-Dichloro-1-propene	75											High		12
Diisopropylamine	83	84		30	20					High		Mod.	Strong	10, 13, §
1,1-Dimethoxyethane	64											High	Aromatic	12
2,3-Dimethylbutane	58	200		< −20										4
2,5-Dimethylfuran	93			45		Slight	Slight					Mod.	Sweet	6, 7
2,4-Dimethyl-2-pentene	83											High		12
Ethyl alcohol	78	43	39.3	65	57	Mod.	Severe			Low	1000	Low	Good	6, 7
Ethyldimethylamine	38	107								High			Strong	10, 13,§
Ethyl nitrate	87			50	50	Severe	V. Sev.					High	Pleasant	6, 7, 12
Freon-113 (1,1,2-trichloro-1,2,2-trifluoroethane)	48	320	5.5	None	None	None	None	None	None	Low		Mod.		—, Table II
Heptane	98	36	30.7	19	25	None	None	None	None	Low	500	Low		—, Table II
Hexane	69	120	8.0	−14	−7	None	None	None	None	Low	500	Low		—, Table II
Isopropyl alcohol	82	32	44.4	70	56	None	None	None	None	Low	400	Low	Pleasant	—, Table II
Methyl alcohol	65	96		60	54	Severe	Severe			Mod.	200	Low		6, 7, 10
Methyl chloroform (1,1,1-Trichloroethane)#	74	100	13.4	None	None	None	V. Sl.	None	None	Low	500	Low	Chloroform	—, Table II
Methylcyclohexane	100	36	25.5	21	25	None	None	None	None	Low	500	Low	Aromatic	—, Table II
Methylcyclopentane	72	110		< −20		None	None					Mod.		4
Methylfuran	63											High		12
Naphtha, Petroleum No. 1	39–190		7.9		20–110	None	None	None	None	Low	500	Low		—, Table II
Propyl ether	90	58		−15	−18					Low	500	High		12
Toluene	110	22	37.5	45	40	None	V. Sl.	None	None	Mod.	200	Low		—, Table II
1,1,2-Trichloroethylene	87	60		None	None	Slight	Severe			Mod.	200	Low		6, 7
2,2,4-Trimethylpentane	100	38	17.8	19	18	None	None	None	None	Low		Mod.		—, Table II
Water	100	17		None	None	None	None	None	None			Low		—, Table II

* Support abrasion-susceptible. † Serious, chronic toxicity. ‡ Serious, acute and chronic toxicity. § Skin irritant. # Inhibited type.

high, moderate or low degrees of health hazard.

This evaluation must be taken only as a guide to the proper handling of these materials. On the basis of information presently available, it is believed to be conservative and to suggest reasonable precaution for protecting the health of those involved in film cleaning.

(3) Chemical Stability

Many organic compounds decompose, polymerize, react with their container, or otherwise alter in composition under conditions of general use or during storage, with attendant changes in physical and chemical properties. Film cleaners for commercial use must have adequate stability to permit shipment in metal drums and storage of partially filled containers for periods of several months. Film cleaners for amateur use should probably be stable for even longer periods of time. All materials whose known chemical stability was inadequate to meet this requirement were eliminated.

Table II. Acceptable Solvents Meeting the General Requirements for Film Cleaning.

	Effect on Film Support						Effect on Tenite Cores		Personnel Hazard	Residue on Evaporation	Electrostatic Discharge Ability	Odor	Cost/Gal.
	Acetate-Propionate		Acetate-Butyrate		High-Acetyl Acetate								
	15 Min.	60 Min.	15 Min.	60 Min.	15 Min.	60 Min.	15 Min.	60 Min.					
1. *n*-Butyl chloride	None	None	None	Chord	None	None	V. Slight Swelling	Mod. Swell.	None	None	Excellent	Ethereal	2.80
2. Carbon tetrachloride	None	None	None	None	None	None	None	None	High	None	V. Poor	Chloroform	1.47
3. Cyclohexane	None	None	None	None	None	None	None	None	Low	None	V. Poor	Aromatic	0.72
4. Cyclopentane	None	None	None	None	None	None	None	None	Low	None	Poor	Aromatic	8.32
5. Freon-113	None	None	None	None	None	None	None	None	Low	None	V. Poor	Chloroform	8.33
6. Heptane	None	None	None	None	None	None	None	None	Low	None	V. Poor	Aromatic	0.19
7. Hexane	None	None	None	None	None	None	None	None	Low	None	V. Poor	Aromatic	0.19
8. Isopropyl alcohol	None	None	None	Sl. Curl	None	None	None	None	Low	None	Excellent	Pleasant	0.50
9. Methyl chloroform*	None	None	None	None	None	None	Slight	Swell.	Low	None	Excellent	Chloroform	1.44
10. Methylcyclohexane	None	None	None	None	None	None	None	None	Low	None	V. Poor	Aromatic	2.57
11. Naphtha, Petroleum†	None	None	None	None	None	None	None	None	Low	None	V. Poor	Naphtha	0.18
12. Toluene	None	None	None	Curl	None	None	None	Swell.	Mod.	None	V. Poor	Aromatic	0.35
13. 2,2,4-Trimethylpentane	None	None	None	None	None	None	None	None	Low	None	V. Poor	Aromatic	3.46
14. Water‡	None	None	None	None	None	None	None	None	None	Salts	Excellent		

*Data obtained from tests of Dow Chlorothene.
†Data obtained from tests of Esso Solvent No. 1.
‡Repeated wetting and drying of some films may produce density changes.

(4) Flash Point

The flash point of a solvent is such a common empirical method of judging its flammability hazard that the value was determined by both the Tag Open Cup and Tag Closed Cup procedures whenever appropriate values could not be found in the literature.

(5) Action Upon Film

It is obviously important that the cleaner have no harmful effects upon either the image or the physical properties of the film.

Stability of the image means no perceptible change in the silver of a black-and-white film, or in the dyes or toned images of a color film. Silver-image stability is now relatively easy to predict in materials of the film-cleaner type, since the most important requirements are no free acidity and no labile sulfur compounds.

The increasing use of color emulsions has added to the complexity of film-cleaner evaluation since a great variety of dyes and color formers are routinely encountered. Therefore, the fact that a solvent meets the black-and-white cleaner standards of purity may not always be adequate.

In the evaluation of solvents upon the dyes of Eastman Color Negative, five strips were prepared for each solvent to be tested, plus five check strips that were not treated with any solvent. Each strip had been exposed in a sensitometer and processed normally to produce a neutral gray scale from which the red, green and blue characteristic curves were determined by the procedures of integral densitometry. Each strip was then cleaned with its corresponding solvent. Next, two of each group of five strips were exposed for 23 hr in a Tungsten Light Stability Test Unit (essentially a tungsten fadometer), two were incubated for two days at 120 F and 90% relative humidity, and the last strip was held at room conditions.

After these treatments, all strips were again read on the densitometer and new characteristic curves plotted. The second set of curves was then compared with the first, noting whether the strips which had been cleaned with solvent changed in any way differently from those check strips which had never been solvent-cleaned. Any differences which would require a change in printing filters equivalent to 0.025 density units or greater were considered cause for rejecting a cleaning solvent.[19]

It is entirely possible to detect seriously dangerous solvents by only a crude approximation of these tests. However, it is important to note that some accelerated keeping conditions may be necessary to show up a dye change initiated by the solvent treatment. Also *the readings must be compared against readings on check strips which duplicate the test strips in every way except for the solvent cleaning.*

All of the solvents in Table II were tested for their action upon the dye images produced in normally processed Eastman Motion Picture Films. In the purity grade which was used, these solvents were found to produce no significant changes in the dyes. We believe, but have not proven, that these same solvents would also be safe for use on the images of other commercial color film products known to us.

Stability of the film base is less easy to evaluate, because nearly every organic solvent will have some action upon film base materials, and the limits of acceptance are harder to define. It was indicated previously that any material with obvious solvent action was rejected immediately. To provide an evaluation of less obvious solvent power, empirical tests were devised, and from these a conservative appraisal was made.

First, for each of the solvents under consideration, an immersion test was made using samples of film coated on commercially important film supports. In the case of Eastman Motion Picture Safety Films, three different types of support have been used; the choice has been based upon the specific requirements of the product and the particular advantages of the support. Included in the immersion tests were films on a high-acetyl cellulose acetate, a cellulose-acetate-propionate, and a cellulose-acetate-butyrate. Also included in the tests was a portion of a film core molded from Tenite II, a cellulose-acetate-butyrate, because it is common practice in commercial laboratories to handle film on plastic cores, and it is a fairly common accident for cleaning solvent to be spilled onto the core.

Observations were made at the end of 15 min and again at the end of one hour. Visual examination showed that as the activity of the solvent increased, the immersed film sample progressed through the following changes: (1) no visual change; (2) increasing curl; (3) softening and gelation of the film base; and (4) complete solution of the film base. The severity of this test is such that the effect on film is greater than would normally be expected for any film-cleaning operation. For this reason solvents were considered acceptable if they produced no more than a slight change in film curl and no visible action on the Tenite core in a 15-min immersion. The test is not considered excessively severe, however, because solvents found to curl the film into a "pipe" or to soften a Tenite core in a 15-min immersion have been a cause for complaints of film distortion — aggravated, perhaps, by slight departures from recommended technique, but still representing situations found in actual film-cleaning practice.

Further qualitative information on solvent activity was obtained by watching

the evaporation of a small drop of solvent placed on the film base. An inactive solvent evaporates without leaving a trace. A more active solvent leaves a ring raised from the base surface. Still more active solvents leave a swollen mound on the base. It is desirable for a solvent proposed as a film cleaner to evaporate and leave no trace.

Finally, information was obtained from a practical test during the cleaning of film with a solvent-moistened flannel pad. The activity of some materials toward film, so slight that merely bringing them into contact with the film support will cause no visible effect, nevertheless is enough to produce a slight softening action. This slight softening then makes it easy for the fabric pad to abrade the support during the wiping operation, resulting in a base haze of myriads of fine scratches.

Because it is easy and obviously desirable to reject seriously active solvents, the real hazard to film lies in the marginally active solvents. It is a basic fact that plastic materials like film base tend to absorb solvents and those most readily absorbed are likely to be least readily released. The absorption of solvents softens and weakens the base, and the gradual protracted and usually nonuniform loss of solvents distorts the film.[6] In our ratings we have tried to be conservative but we realize that it is possible to choose unfavorable techniques and thereby damage film with any solvent.

(6) Cleaning Efficiency

Solvents which passed the various tests so far were next examined for their efficiency in removing foreign matter from film, for their tendency to leave a residue, and for their electrification propensities.

Residue on evaporation may indicate accidental dissolved solids or oils representing contamination of a solvent, or may indicate intentional additions to a proprietary film cleaner. Inasmuch as film-cleaning solvents are necessarily good degreasers, some such contamination is frequent. Furthermore, it is not uncommon for a proprietary cleaner to have dissolved solids intentionally added for controlling static electrification of the film or for film lubrication. Examination of the residue upon evaporation of such cleaners indicates whether one may expect to encounter difficulty with streaking when using the material.

In some cases a residue on evaporation appeared to result not from dissolved material originally present in the solvent, but from foreign matter on the film, dissolved by the solvent, and then deposited in an objectionable manner upon solvent evaporation.

In the first test for residue, a large drop of the substance under consideration was placed on the emulsion side and another on the support side of flashed and processed Eastman Color Negative as it lay on the cleaning table top. These drops were allowed to evaporate freely to dryness. To a certain extent this duplicates what might occur during film cleaning if excess solvent is used. In the second test, the material in question was applied to the film with a pad of flannel, care being taken to see that no droplets were left on the film. Any residue after either test was further examined to see whether it was readily removed or made unobjectionable by buffing, or if, in the normal use of the cleaner, it was difficult to avoid streakiness and mottle on the cleaned film. Generally, single pure solvents were rejected if they left any residue; proprietary cleaning mixtures for which the residue was believed to represent intentional additives were rejected if the residue could not readily be buffed to a uniform invisible layer.

Removal of oil and dirt was judged by cleaning a portion of a projection print which had accumulated a considerable amount of various dirts, oils, etc., typical of a print which has seen considerable normal service. Ability of the solvent to clean such film was taken as evidence of its usefulness in extreme cases.

Electrification tendencies represent another solvent property affecting the ability of a material to clean film satisfactorily. Film which acquires a static potential attracts dust, lint and other particles, so that even though it may have been clean momentarily, it may at the time of future use be objectionably dirty. The operations of film cleaning generate static charges on the film by the separation of surfaces as the supply roll unwinds, and by the frictional effects of drawing the film through a cleaning pad. Therefore, it is important to note whether the solvent aids in discharging this potential, leaves it unchanged, or actually aids in generating still higher potentials. The performance of several typical cleaning solvents has already been reported.[7]

The effect on electrification of film-cleaning solvents can be evaluated by first charging the film to several known levels, both positive and negative, then passing the film over a cleaning pad which is suitably moistened with the test solution, and finally noting the resultant charge level. The electrostatic discharging abilities of the solvents under consideration were determined in this manner. In the ratings given in Table II, "Excellent" means that cleaning with that solvent removes practically all the electrostatic charge from the film regardless of the film's initial potential. A "Poor" discharge rating indicates that cleaning with that solvent removed very little or none of the electrostatic charge. A solvent rated as "Bad" acts very erratically or even increases the charge on the film. It should be noted that these ratings apply only to the immediate effect upon the electrostaitc charges during the film-cleaning operation; none of these solvents leaves any residue to affect subsequent electrification.

(7) Availability and Price

Availability was judged from the listing of the solvent in the market reports (in the *News Edition of Industrial and Engineering Chemistry*, or in the *Paint, Oil and Drug Reporter*) or its inclusion in the list of Eastman Organic Chemicals. Price comparisons were made within each of these tabulations to eliminate solvents whose cost was greater than that of Freon-113. It is probable that this method of judging price and availability is conservative and that no reasonable materials were rejected in this stage. The prices given in Table II are for guidance in estimating the relative costs of various materials and are not necessarily precise quotations.

VII. PRACTICAL SOLVENTS

After the various possible solvents had been screened, and the list reduced by considering in turn the various requirements of a good film-cleaning solvent, there remained a group of 14 solvents, any one of which is an acceptable film cleaner.

These acceptable solvents are listed in Table II, and their distinctive properties are discussed in this section.

(1) n-Butyl Chloride

This material very closely resembles carbon tetrachloride in evaporation rate and is probably less hazardous. The combination of a rather low flash point and a rather high price, however, indicate that it will have only limited applications.

(2) Carbon Tetrachloride

Except for high toxicity this material is ideal as a film-cleaning solvent. In the future it will probably be employed only in the largest film-cleaning installations where it will be practical and economical to provide proper ventilation, industrial hygiene and medical service for protection of the personnel.

(3) Cyclohexane

Among the hydrocarbon film cleaners, cyclohexane is the closest to carbon tetrachloride in evaporating rate and it has a flash point toward the upper range of the suitable hydrocarbon group. In common with all the hydrocarbons, it is not effective in discharging electrostatic potentials from the film.

(4) Cyclopentane

This is equivalent to cyclohexane in nearly all important qualities. It does show a higher rate of evaporation and at the same time has one of the lowest

flash points of the materials in Table II.

(5) Freon-113

Freon-113 (trifluorotrichloroethane) shows low toxicity in experimental animals, and in this respect is similar to methylene chloride. It should be handled with the usual precautions recommended for most halogenated solvents, but occasional exposure to low concentrations from film cleaning is not considered hazardous.

Freon-113 would be a valuable cleaner for small-scale use except for its two major disadvantages: high cost and high volatility. It is an expensive material to use for film-cleaning purposes not only because of its high cost per unit volume, but also because its more rapid evaporation rate means that a given volume effectively will clean a lesser footage of film. Dilution, to offset both its high cost and high rate of evaporation, is possible and it is usual to use hydrocarbons for such dilution. Such diluents are flammable, however, and the mixture frequently shows a flash point similar to that of the diluent when the amount of Freon is reduced to 50% or slightly less. Dilution with solvents more toxic than Freon offers little advantage.

(6) Heptane

Showing only slight toxicity, heptane is a good film cleaner and one of the least expensive. Its principal drawback is flammability and the flash point is low enough so that substantial precautions need to be taken.

(7) Hexane

This material is identical in film-cleaning ability with heptane, but is preferred in some applications because of the more rapid evaporation rate. The flash point is very low, but it is still practical to set up working conditions which provide proper precautions for this hazard.

(8) Isopropyl Alcohol

The only alcohol included in this table, isopropyl, is a compromise between the lower alcohols, which are somewhat more rapid-evaporating but at the same time have significant solvent attack on film supports, and the higher alcohols which resemble the aliphatic hydrocarbons but have longer evaporation times.

(9) Methyl Chloroform

The substance whose properties most closely approximate those of carbon tetrachloride is methyl chloroform (1,1,-1-trichloroethane). It is a good solvent for grease and oil, exerts no adverse effect on film, and has no flash point. Although clinical data are still relatively limited, it appears probable that methyl chloroform is much less hazardous than carbon tetrachloride for either acute or chronic exposure. Its major drawback has been its corrosiveness to aluminum, zinc, and their alloys. However, much work has been done to correct this difficulty and it is now possible to incorporate in methyl chloroform small percentages of known inhibitors which prevent attack on metals without any reduction in film-cleaning efficiency. Among the known inhibitors are dihydropyran, dioxane,[2] and 2-methyl furan each of which will successfully inhibit the corrosive attack of methyl chloroform and permit the liquid to be used in the presence of aluminum and zinc alloys.

Although it is certainly advisable to use only corrosion-inhibited methyl chloroform because of the common presence of susceptible materials on film-cleaning equipment, rewinds, viewers, splicers, etc., it is at the same time necessary that there be some control over this inhibitor as a precaution against possible harmful effects to the film. The inhibitors actually have considerable solvent power for film base and by themselves would be completely unsatisfactory as film cleaners. Our tests using methyl chloroform as a film cleaner, however, show that if the material has evaporated completely before the film reaches the windup-reel any one of the three inhibitors listed above can be incorporated without harmful effects. The amount of inhibitor is approximately 5% so that it evaporates readily with the main volume of methyl chloroform. Thus it does not complicate the use of the cleaner. If, at any time, it is proposed that some other inhibitor be incorporated, however, tests should be run to insure safety to the film.

(10) Methylcyclohexane

The chief distinction among methyl cyclohexane, hexane and cyclopentane is their variation in evaporation time. In operations where longer evaporation times are desired, methyl cyclohexane may be preferred.

(11) Naphtha

Representing the least expensive of the aliphatic hydrocarbons, naphthas can be used where their low flash point and rapid evaporation rate are not handicaps. Since the composition is not so clearly defined as that of the sharper fractions such as heptane and hexane, however, it should be purchased on specification so that successive lots will perform in the same way. It is unlikely that harmful contaminations will be present, but the evaporation rate and, therefore, the optimum cleaning technique, may vary widely in naphthas obtained from different suppliers.

(12) Toluene

Toluene is one of the aromatic hydrocarbons classed as moderately toxic and at the same time possessing desirable physical properties. It is considerably less expensive than the other comparable hydrocarbons, moreover, and may have applications where its lower evaporation rate is not objectionable.

(13) 2,2,4-Trimethylpentane

Although this solvent is intermediate in evaporation rate between heptane and hexane it is probable that its high cost makes it of little commercial interest at the present time.

(14) Water

Cleaning with water offers a great many obvious advantages but the technique is so much different from that for cleaning with organic solvents that the next section is devoted to the details of this procedure.

VIII. CLEANING WITH WATER

Oils, grease, dust and dirt may be removed efficiently from many types of surfaces by the use of water and detergent. The major problem, when these are applied to motion-picture film, has been to devise reasonable techniques that would avoid film damage. Recent experimental work has shown that practical film cleaning with detergent in water can be obtained with relatively simple equipment.

The principal simplification is the use of an impingement drier to minimize the time of treatment and the thread-up path. Earlier work by Miller[21] has established a sound basis for the design of impingement drying equipment and such driers have already been used in commercial applications. It was obvious from the earliest consideration of cleaning with water and detergent that the immersion times in liquid could be kept short with the result that the water pickup of the film, in many cases, would be less than that obtained during complete processing. These features can be incorporated in equipment of extremely simple design such as that shown in Fig. 1.§

Development of a Cleaning Method

On small-scale experimental equipment, the cleaning of used projection prints was investigated to determine what would be necessary for the complete cleaning of extremely dirty films. Nacconol NR‖ was selected as a typical anionic detergent with good wetting properties. Only a limited number of other detergents have been investigated but it is believed that a great many could be used for successful film cleaning.

Studies of detergent concentration indicated that about one-tenth of one

§ Further studies on the detergent cleaning of film have been made by John R. Turner[22] as reported on April 30, 1956, at the SMPTE Convention in New York.

‖ Trade name of Allied Chemical & Dye Corp., National Aniline Div.

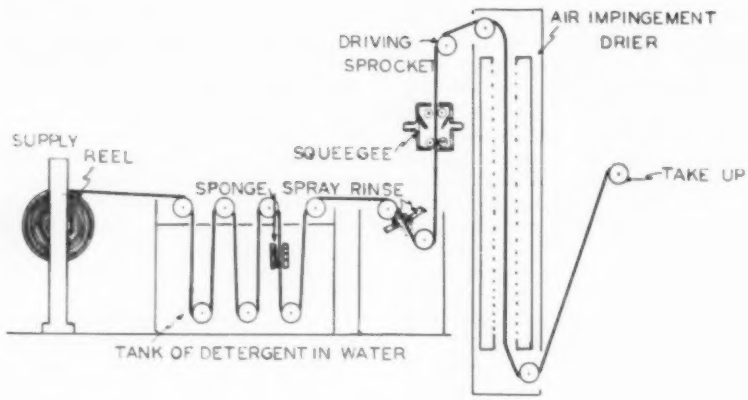

Fig. 1. Film-cleaning machine using water plus detergent.

Table III. Water Absorption of Films During Detergent Cleaning.

	Percent Moisture Measured After Squeegee	
Film type	Detergent cleaning	Normal processing
5231, Plus-X Panchromatic Negative Film	26	35
5248, Eastman Color Negative Film	10	30
5302, Fine Grain Release Positive Film	9	17

percent of Nacconol NR in water was an appropriate level. The soiled film was passed through an unagitated detergent tank and the study made of necessary immersion times for effective dirt removal. In such an unagitated tank, it was determined that some surface action was necessary to remove dirt which had been wetted and loosened but still remained adhering to the film surface. A stationary submerged viscose sponge, contacting each side of film, was used during the experimental work. In the commercial use of this technique the rotating, submerged and self-cleaning sponges commonly used on processing machines would be more satisfactory and it may be that submerged jets for the recirculation of the detergent solution could take their place. With the surface action provided by a stationary sponge, a minimum immersion time of 30 sec was found necessary for the removal of oil and dirt from processed film. This time was increased to 60 sec to insure complete cleaning. A series of tests on the cleaning and drying of various Eastman Motion Picture Films was then made.

Study of the Drying Problem

Table III lists the water content of each of three standard films after 60-sec immersion followed by effective removal of all of the surface moisture by an efficient squeegee. It will be noted that Eastman Fine Grain Release Positive Film, Type 5302 and Eastman Color Negative Film, Type 5248 both picked up significantly less moisture than they would have absorbed in normal processing. On the other hand Eastman Plus X Panchromatic Negative Film, Type 5231 picked up almost 65% as much in 60 sec as it would have acquired during normal processing. These variations in water pickup have some influence on the drying curves, as will be discussed later. The importance of good squeegeeing has been emphasized in all discussions of impingement drying since the cabinet is not designed to take care of surface droplets.

A peculiar phenomenon was observed during these studies of film cleaning whenever the air pressure dropped to the point where the squeegee was no longer operating satisfactorily. When film left the squeegee with *any* surface water the emulsion rapidly developed a mottled and pock-marked surface which subsequent drying would not remove. Once the trouble was traced to the squeegee and corrected, however, there was no emulsion pitting on any of the later samples.

Drying curves for the three Eastman films in Table III are given in Figs. 2, 3 and 4, representing the residual moisture as a function of time when drying with air heated to various temperatures. These figures also compare the curve obtained for drying with 150 F air with the curve obtained by Miller[21] for drying with 150 F air after processing. It will be noted that the drying proceeds more rapidly for Types 5302 and 5248, but that for Type 5231 (where the original moisture contents were more closely alike) the two curves are practically superimposed. Table IV summarizes the drying times necessary in the experimental impingement drier to reduce the moisture contents of the film to that

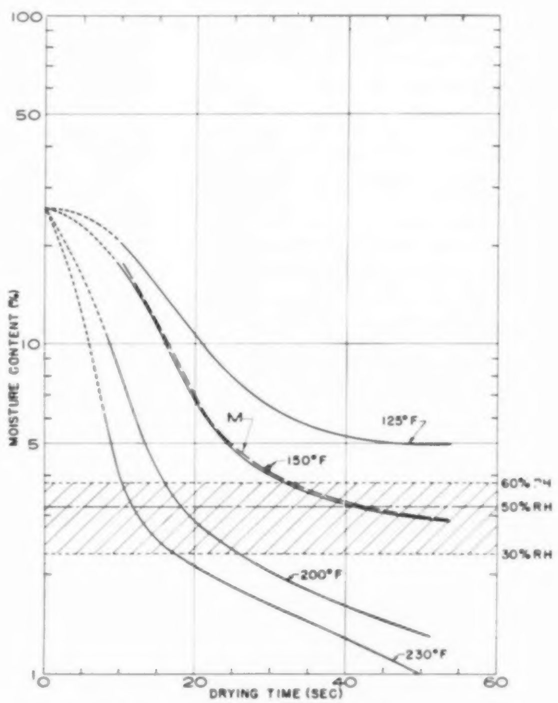

Fig. 2. Rate of drying for Eastman Plus-X Panchromatic Negative Film, Type 5231 during impingement drying after detergent cleaning, as discussed in text. Curves indicate dependence of rate upon temperature of drying air. Curve M indicates comparative data from Miller[21] for drying after complete processing.

Table IV. Summary of Drying Times: Impingement Drying Following Detergent Cleaning.

Film Type	Drying Time in Seconds, to Reduce Moisture Content to Equilibrium With 70 F, 50% RH			
	Air 125 F	*Air 150 F*	*Air 200 F*	*Air 230 F*
5231, Plus-X Panchromatic Negative	>60	40	18	11
5248, Eastman Color Negative	23	16	8	6
5302, Fine Grain Release Positive	8	6	4	3

representing equilibrium with 70 F at 50% RH.

It is apparent from these curves that the necessary drying time for film cleaned in detergent and water is no more than the drying time after normal processing and for some types of film will be significantly less.

Precautions for Cleaning With Water

There are some differences between the problems of processing film and those of cleaning film with detergent and water which should be emphasized. To a certain extent these precautions dictate the equipment design and may also limit the applications of water cleaning.

Mechanical design of the cleaning machine must provide for low film tensions because the film to be cleaned will probably contain a number of splices, and it will therefore be extremely important to guard against film breaks. On the other hand, the very short thread-up path necessary for immersion and impingement drying makes it very easy to maintain minimum film tensions by good mechanical design. It will be necessary also, of course, to protect against the possibility of abrasion because the detergent solution will soften the emulsion to a greater extent than any of the organic solvents considered. This should not be a major problem because it has been solved many times in the design of every processing machine.

Dye bleeding has been no problem with any of the Eastman Color Films. One would not expect any problems with films which in their normal processing are washed after the formation of the color images. Certain imbibition print films, however, will show dye bleeding when cleaned in detergent and water and films of this type cannot be successfully treated.

Certain films in normal processing are treated with stabilizers before the final drying. In some instances these stabilizers are water-soluble and might tend to be removed by the cleaning with detergent solutions. In such a case, it might be necessary to follow the water rinse with a restabilizing bath preceding the impingement dryer. Such problems would have to be worked out after a careful study of the particular film type involved.

When projection prints are cleaned in a water-detergent system, the film surfaces are brought back essentially to the "as-processed" condition. Therefore, relubrication may be necessary to avoid unsteady projection, excessive perforation wear, and the other high friction characteristics of a "green print."

Films stored under certain conditions are known to support the growth of microbiological organisms and it is possible that such stored films will from time to time require cleaning before printing, duplication, etc. An early result of such microbiological attack is the degradation of the gelatin in the emulsion to make it more water-susceptible and, in some cases, to solubilize the entire emulsion layer.[15] Films showing damage of this sort would, of course, be ruined completely if cleaned with any water solution. Films showing such attack are usually readily identified by visible inspection and it will be important to

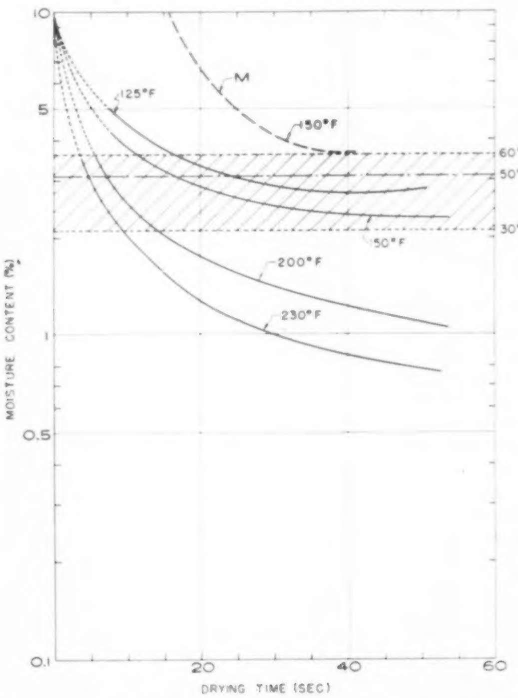

Fig. 3. Rate of drying for Eastman Color Negative Film, Type 5248 during impingement drying after detergent cleaning, as discussed in text. Curves indicate dependence of rate upon temperature of drying air. Curve M indicates comparative data from Miller[21] for drying after complete processing.

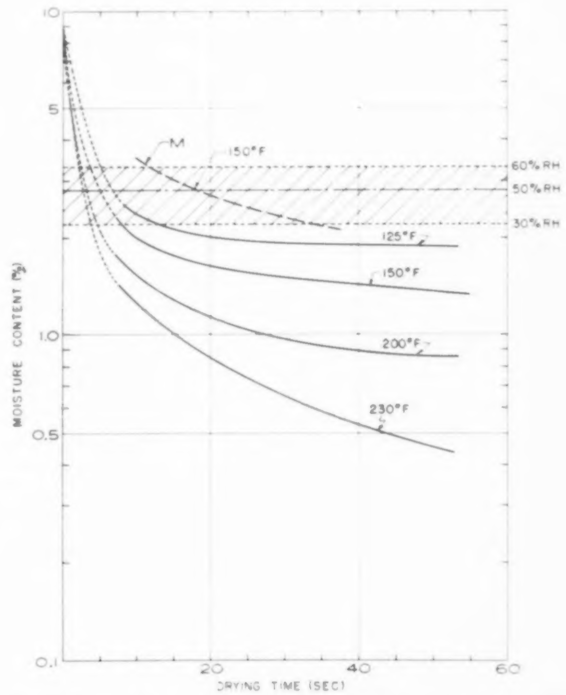

Fig. 4. Rate of drying for Eastman Fine Grain Release Positive Film, Type 5302 during impingement drying after detergent cleaning, as discussed in text. Curves indicate dependence of rate upon temperature of drying air. Curve M indicates comparative data from Miller[21] for drying after complete processing.

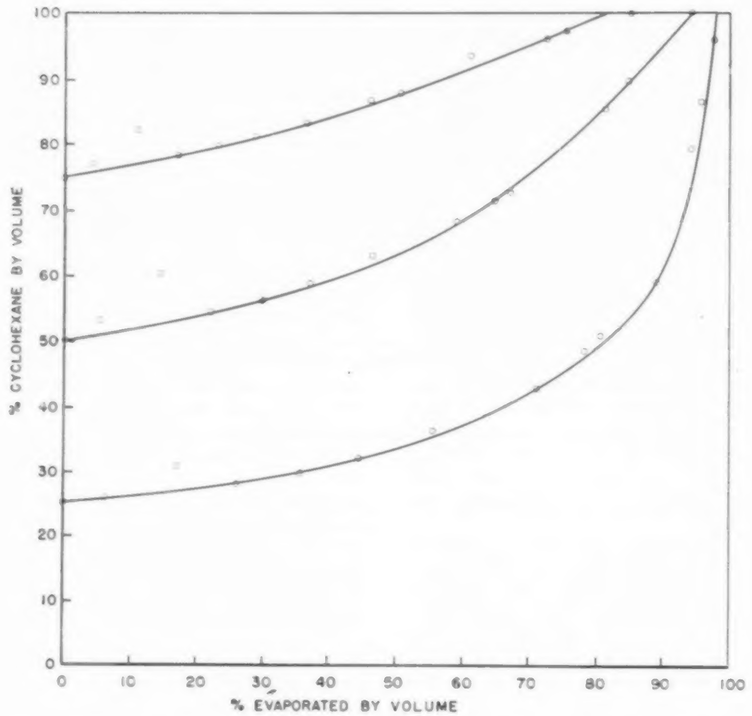

Fig. 5. Change in composition during evaporation at room temperature of mixtures of Freon-113 with cyclohexane.

see that such films are never cleaned with detergent and water.♯

IX. MIXTURES OF SOLVENTS

The properties desired in a film-cleaning material for a particular application may not always be found in a single solvent, and so it often becomes desirable to resort to a mixture of solvents. The advantages of mixing are that one may sometimes obtain reduction of the hazard attending the use of a toxic or flammable material, offsetting of the cost of a highly priced component, alteration of evaporation rate to a more desirable level, etc. It is difficult in this discussion to treat mixtures adequately because so very many mixtures are possible. These comments, therefore, merely point out some of the problems in formulating binary mixtures of solvents, and generalize on results. Ternary and more complex mixtures are completely beyond the scope of this paper.

Evaporation rate tends to be intermediate between the components providing there is no interaction between the solvents. On the other hand, interaction is so common it should be *expected* that mixtures of chemically dissimilar solvents will form azeotropes — that is, there will be a certain mixture of the two solvents which acts like a new compound and vaporizes without a change in composition.

All solvent mixtures will change in composition during evaporation except those mixtures which have precisely the composition of an azeotrope. Such changes are seldom important for the solvent actually used on the film, but they may be very important for the solvent stored in a container that is not tightly sealed. This is especially important in the case of a film cleaner which is composed of a nonazeotropic mixture. Here the user may find that cleaner which he has had on hand for some time has changed in composition, and may no longer be nonflammable or no longer have some other intended property.

Figure 5 illustrates the change in composition of mixtures of Freon-113 and cyclohexane with evaporation at room temperature, indicating that all three initial mixtures become much richer in cyclohexane upon standing.

There is no indication in these data of any azeotropic mixture of Freon-113 and cyclohexane, and furthermore the residue on evaporation of all three starting mixtures approaches pure cyclohexane. The flash point depressing action of Freon-113, of course, is thus effectively reduced, and the residues become more flammable.

Health hazard of a material depends partly on the amount of that material to which a person is exposed; therefore, dilution with a less toxic material may reduce the hazard providing the partial pressure of the toxic solvent over the mixture is reduced accordingly. Thus, dilution of carbon tetrachloride with a hydrocarbon may reduce the health hazard of the mixture. On the other hand, it is difficult to dilute with more than about 50% of a flammable material without having the mixture show a flash point, and a 50% reduction in the vapor concentration of a material as toxic as carbon tetrachloride is usually an inadequate reduction.

Furthermore, there is a very real possibility of the mixtures presenting increased toxic hazards because of synergistic effects. Evaluation of such synergistic effects may require extensive toxicologic and clinical investigation.[15]

Chemical stability as a general rule is not changed by the mixing of solvents.

Flash point of a mixture is not changed in as straightforward a manner as the vaporization characteristics. In most cases, the flash point is an independent property and in many mixtures of solvents often approximates that of the lowest flash point material in the mixture. However, by mixing a flammable solvent with a sufficient quantity of a substance having a high vapor pressure and no flash point, a blanketing effect can be produced resulting in a nonflammable cleaner.

It must be remembered, however, that the flash point test is highly empirical, and measures flammability properties under a particular set of circumstances — which may be different from those existing during the use of a film cleaner. Mixtures with no flash point may actually be hazardous in use, and those with a low flash point may actually be quite safe under certain conditions.

Reaction with film is also difficult to predict. Mixtures of materials, each of which alone is quite inert to film, will in some cases show an extremely rapid rate of attack on the film. Freon-113 plus methylene chloride is such a mixture. This type of complementary solvent power is unpredictable, although it has been known for a long time. Hydrocarbons, for example, increase the solvent power of alcohols, while alcohols, in turn, increase the solvent power of chlorinated solvents. Complementary solvent power is generally observed in mixtures of chemically dissimilar materials, and seldom occurs in mixtures of homologues.

We have observed this increase in solvent power above that of any constituent in a number of formulas considered

♯ Films subjected to microbiological attack sufficient to solubilize the gelatin usually will show a pattern in the emulsion detracting from optimum photographic quality of the image. Such films can be safely cleaned with the organic solvents listed in Table II and these solvents will effectively remove surface dirt but will not remove or correct the growth pattern present within the image. Even such partial cleaning is sometimes important for particularly valuable films which it is desired to copy or to protect from further deterioration.[16]

as possible commercial cleaners, including the following:

Cleaner A . .	Freon-113 . . .	25%
	Trichloro-ethylene . . .	75%
Cleaner B . .	Trichloro-ethylene . . .	50%
	Isopropyl ether .	35%
	Hexane	15%
Cleaner C . .	Denatured ethyl alcohol	90%
	Water	10%
Cleaner D . .	Toluene	80%
	Methyl alcohol . .	20%

These mixtures, in our opinion, are too active for use. In addition, Cleaner B caused difficulty because the particular commercial grade of isopropyl ether contained an impurity which had considerable photographic activity and fogged unprocessed emulsions.

Cleaning efficiency is the one property which seems completely predictable in a mixture of solvents.

Price and availability are frequently the most compelling reasons for the dilution of expensive materials.

X. TECHNIQUE IN FILM CLEANING

The success of a film-cleaning operation is contingent upon a number of factors in addition to the choice of solvent, with the most important being listed below.

Cleanliness of Work Areas and Materials

Film cannot be cleaned in a dirty place. Commercial laboratories find it desirable to isolate negative-cleaning areas from all other activities, keeping all doors closed, limiting access to the area, restricting types of clothing worn, and sometimes supplying special clothing with less linting tendencies,[22] and even providing personnel cleaners, etc., at the entrance.

Areas designated for film cleaning should be vacuum-cleaned frequently because air currents, movements of personnel, and the normal activities of a day's work distribute dirt over wide areas. Particular attention should be paid to the actual surfaces which the film might approach or touch, such as the top of the rewind table, the take-up reel, the interior of a drying cabinet, etc. Vacuum cleaning is required because it is necessary to remove the dirt and not merely redistribute it.

Smoking should be prohibited because the tobacco and paper ash fly widely and adhere readily to the film. Foods should also be kept out of the film-cleaning area.

Clean solvent is essential and a reasonable amount must be used not because of the limited solubility of the dirts but because the evaporation of even a thin layer of dirty solvent will leave the film mottled and uncleaned. Therefore, one must use an amount of solvent consistent with the quantity of dirt to be removed. It will be found also that when film is wound up wet with solvent, dirt streaks and smears are encouraged. For proprietary solvent cleaners containing dissolved solids, this usually produces severe mottle.

Ventilation and Exhaust for Dirt and Solvent Control

Careful ventilation will control both airborne dirt and solvent vapors. In order to provide such control, however, the direction and volume of air flow must be correct, and air which has picked up dirt or solvent must be exhausted effectively.

Dirt-control measures are selected according to the importance and cost of minimizing dirt. Table V lists the types of ventilating supply and exhaust in order of increasing effectiveness. Best operating conditions, obviously, combine care in the cleaning of air with maximum enclosure of the film-cleaning area. Techniques of air filtration have been discussed by Simmons and Robertson.[22]

Solvent control usually determines the air volume and flow requirements — based upon the nature of the solvent, the method of venting, and upon whether the hazard is toxicity alone or whether the vapors are also inflammable. In both cases sufficient air must be supplied to dilute the vapors below some proper limit. For a toxic solvent, this dilution is essential only in the areas occupied by personnel. However, when flammable materials are involved it is equally hazardous to reach an explosive limit in the presence of personnel, in exhaust ducts or, in fact, anywhere about the operation.

Generally speaking, there are three methods of controlling solvent vapors: (1) general ventilation or dilution; (2) local or regional exhaust; (3) complete enclosure of the hazard combined with exhaust. In the first, sufficient fresh air is supplied to dilute all the solvent vapors to the permissible limit of concentration; in the second the vapors are captured and removed at their point of origin so that protection is afforded by a curtain of air at sufficient velocity; in the third the solvent vapor is confined by a physical barrier and removed by air exhaust. The choice of method is a matter of convenience and compatibility with the equipment desired.

Ventilation must control solvent vapor from three primary sources: (1) the section of film being cleaned; (2) the plush or cloth used for cleaning; and (3) the supply can of solvent. All three sources must be within the path of sufficient air flow properly directed and arranged to avoid stagnant pockets of high concentration.

Evaporation of solvent before the film reaches the take-up reel — specified earlier as essential to prevent solvent effects on the film — requires a balance among (1) amount of solvent applied; (2) efficiency of wiping or squeegeeing; (3) length of drying path; and (4) speed of film travel. This balance can be achieved even with relatively slow evaporating solvents such as trichloroethylene (as has been demonstrated in some commercial cleaning machines). At the other extreme it is possible to clean by hand with relatively fast-evaporating Freon-113 and have the balance so unfavorable as to wind up wet film.

Table V. Preferred Air Supply and Exhaust Systems for Optimum Control of Air-Borne Dirt (listed in order of increasing effectiveness).

Air Supply	Air Exhaust
1. Unselected	1. Uncontrolled
2. Selected	2. Room
3. Filtered	3. Local
4. Conditioned and filtered	4. Enclosed and local

Solvent should be kept in a closed container. For dispensing purposes the spring-topped safety plunger cans of about one-pint capacity are satisfactory. They meter solvent conveniently to any cleaning pad pressed down onto the plunger cap, without danger of spilling or flooding.

Cleaning-cloth surfaces should be renewed frequently so that the solvent does not transfer dirt from the cloth to the film, and should at all times remain within areas where ventilation is adequate to remove the vapors.

Used cloths should be placed immediately in a suitable tightly closed container and not allowed to evaporate their solvent into the room. Where effective local exhaust is available and the volume of used cloths is not large, it may be permissible to place used cloths adjacent to an exhaust grille. When such precautions are not routinely observed, it may become very difficult to control the health hazard from solvent vapor.

Air flow should always be from the operator to the work area to the exhaust — so that the operator breathes relatively fresh air, and the solvent vapors are swept into the exhaust duct. One of the most successful simple procedures for ordinary hand-cleaning operations has been the installation of baffles on a rewind table to make the most efficient use of exhaust air currents, coupled with an exhaust grille in the vertical "bang-board" at the back of the table but as close to the work area as possible. This arrangement is illustrated in Fig. 6 where it will be seen that vapors are drawn away from the operator, across the tabletop to the exhaust.

Shielding the operator from the vapors is sometimes helpful. In a film-cleaning machine, of course the cabinet doors

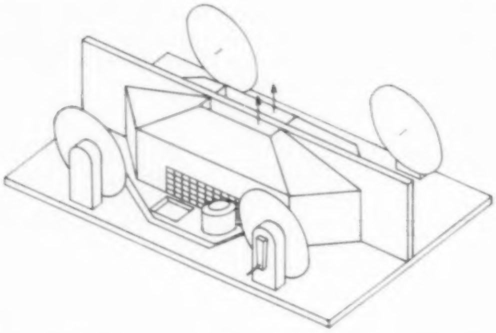

Fig. 6. Film-cleaning bench for manual cleaning with local solvent vapor exhaust. For dimensions and discussion see Appendix, Case II. (The duct carrying the central exhaust to the fan has been omitted for clarity of bench details.)

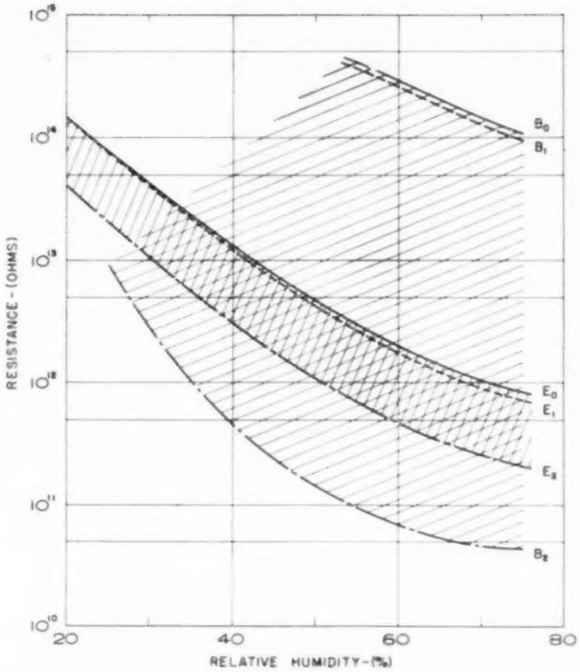

Fig. 7. Effect of antistatic additives upon the surface resistance of motion-picture films. Curves E_0 and B_0 are representative of the variation in electrical resistance for the emulsion and support surfaces, respectively, of typical, processed Eastman motion-picture negative films. Curves E_1–E_2 indicate the minimum and maximum effects we have observed from the use on the emulsion of a cleaner containing an antistatic additive. Curves B_1–B_2 are similar data for the effects upon the support resistance. In both cases, the minimum effects are typical of many commercial proprietary cleaners; the maximum effects are seldom achieved, and then only with great risk of streak and mottle during the application.

perform this function. For hand cleaning at a rewind table a glass or clear plastic baffle can be so located that the film is under a transparent shield, in full view and under easy examination, but without a direct vapor path from the solvent area to the operator's face.

Final check of ventilation efficiency is best obtained by actual air analysis for solvent vapors. Analytical services are maintained by many insurance companies, by municipal and other governmental departments of labor, fire prevention, etc., and by private consulting laboratories.

Air-Conditioning

Whenever complete air-conditioning including the careful filtration of air can be justified, the increase in efficiency of film-cleaning operations will be significant. Control of humidity to a level approximating 50% to 60% RH (Fig. 7) is further helpful in reducing film electrification tendencies and the resultant reattraction of dirt. It aids in improving air cleanliness because of the washing of air in the conditioner. Such humidity regulation will also control film curl for optimum handling.

Film Inspection

As a part of the film-cleaning technique, film inspection cannot be overemphasized. Inspection can indicate the need and the proper frequency for cleaning, the type of dirt, and much about the film's condition.

Splices in need of repair are best detected before they catch in the film-cleaning cloth with the possibility of tearing several frames, or before the film separates in a cabinet with chances for extended abrasion. Accidental damage, too, is always less serious when repaired early.

Identification of the type of dirt can be particularly helpful when the dirt is localized. For example, tape residue, marks made with wax editing pencils, splicing cement residues, etc., are best cleaned locally with careful attention, rather than by a haphazard general cleaning.

Examination for the presence of film lacquers, protective treatments, and scratch - removal applications is important. Treated films should be cleaned only in the manner prescribed for that specific treatment. Otherwise the appearance of the film may be made worse or the effect of the treatment nullified.

XI. PLUSH AND CLEANING CLOTHS

The cleaning cloth has a unique contribution to the success of film cleaning because all of the dirt removed from the film usually ends up on the cloth. The cleaning cloth, therefore, must provide for the ready absorption of dirt and grit so that film surfaces are not continually scrubbed with the dirt removed from other surfaces. This is a prime advantage of plush and of many loosely woven fabrics. For dry cleaning, the problem of dirt disposal almost completely eliminates anything but plush. Even this has a small enough dirt-carrying capacity so that frequent or continuous vacuum cleaning of the plush is necessary to minimize abrasion. Wet cleaning, on the other hand, is somewhat less critical because the solvent partially flushes dirt into the cloth pad or at least keeps the grit from imbedding only on the contact surfaces.

Necessary attributes of the cloth require first that it be clean and soft in order to avoid film damage. At the present time the fabrics most commonly used are plush, flannel, batiste, nainsook and cheesecloth.

Lint from the cloth frequently is as objectionable on film as the dirt one is attempting to remove, so that those fabrics with firmly bound fibers have an advantage. The continuous-filament synthetics offer promise in their inherent freedom from short-fiber lint. Equally important is the fiber problem at cut edges where nearly all fabrics produce many free linters. Cleaning plush is often hot-cut to provide a sealed edge that will not ravel. Other cloths are folded into cleaning pads with the cut edges buried inside.

The successful film-cleaning operation requires control of solvent flow and frequent renewal of the cloth surface so that dirt already on the cloth is not redeposited on the film. This problem is emphasized by the material balance

of Fig. 8. Much of this is done naturally in the mechanized and large-scale film-cleaning operations. The trouble may most easily occur in the occasional or amateur cleaning operations where the limited useful life of the cloth is not nearly so obvious as the limited capacity of the film-cleaner bottle.

For this reason there is a distinct advantage in white or light-colored cloths; it is more obvious when they become dirty. Colored or even black cloths will clean as well (providing their dyes are fast to the solvent used), but there is a tendency to use them long after they have absorbed enough grit to abrade the film, or enough oil to reapply it to the film.

Some physical action of the cloth is desirable to facilitate cleaning, because frequently dirts will be partially loosened by the solvents but will not flush away cleanly without wiping. Such action is obtained from a plush, or from a suitably prepared soft pad of fabric so supported as to bring it into contact with the entire film surface under very light but positive pressure.

Finishing materials are commonly present on textiles because the manufacturer finds they ease the manufacture or aid the sale of the cloth. These may include pigments, sizing materials, spinning oils, products to improve the feel of the fabrics, and now a host of crease-resisting, soil-limiting chemicals — many of which are readily extracted from the cleaning cloth by film-cleaning solvents. Extraction tests in our laboratories definitely have established that many streaks that have been blamed on inadequate cleaning, redeposition of lubricants, blushing of lacquers, etc., are in reality the deposition on the film of material extracted from the cloth by the cleaning solvent.

To emphasize the amount of extractable material, Table VI presents the data on 14 unused samples of cloths *actually employed* for film cleaning. In these tests, cloth samples of known area and weight were placed in Soxhlet extractors and extracted for 24 hr with specially distilled carbon tetrachloride. At the conclusion of this period the extracting solvent was transferred to a tared beaker and evaporated to dryness on a steam bath. The increase in weight of the beaker was taken as the weight of material extracted from the cloth. Similar results can be obtained with other solvents. The values in Table VI, although numerically small, appear quite large when the proper relationship to the problem is established.

A film lubricant, for example, will contain about 0.1 g of a specially chosen material per 100 ml of solvent — and one requirement of the additive is that it dry to a smooth glossy surface. Most additives dry to an objectionable "blushed" surface. Thus, a piece one foot square of sample B, one of the worst materials in the table, actually has enough soluble material to make 500 ml of a 0.1% solution, or about 4 hours supply in normal hand cleaning. If we dilute this solution enough to dry without streaking, its volume would be several times as great. Therefore, the initial use of this cloth will actually produce a dirty smeared surface even though the film itself had originally been clean! For this reason it appears it would be good insurance to launder the cloths before use, since many common finishers can be eliminated thereby.

As a proposed screening test for selecting suitable cleaning cloths, it is suggested that an extraction test be made on the cloth using the actual film cleaner as the extracting solvent. Extraction for 24 hr should give an extract weighing not more than 0.1 g/sq ft of fabric, and the residue should be dry and not tacky.

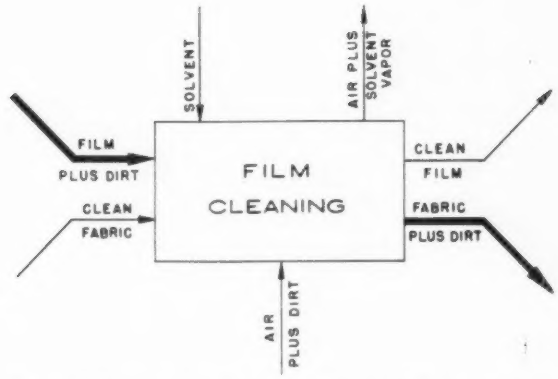

Fig. 8. Material balance in solvent-cleaning of film. Note that if the film is cleaned, the dirt *must* be transferred to the cloth and removed with it.

Table VI. Solvent Extraction of Cleaning Cloths. Material Soluble in Carbon Tetrachloride Extracted From Unused Samples of Cloths Obtained From Motion-Picture Film Laboratories.

Sample	Description	Weight of Cloth, g/ft²	Extract: % of Cloth Wt.	Extract: Appearance
A	Black plush	29	1.8	Cyan-black
B	Black velvet	32	0.7	Dark red
C	Orange Softone Velour	40	0.5	Yellow-orange
D	Dry-cleaning velvet, white	57	0.4	Greenish-yellow
E	Imported velvet, white	22	0.2	Yellow-brown
F	Pink flannel	13	1.2	Yellowish
G	Canton flannel	11	1.2	Yellowish
H	Canton flannel	24	0.5	Yellowish
I	White batiste	4.9	0.5	Milky, spotted
J	Batiste	7.5	0.5	Milky, yellow
K	Nainsook	6.1	0.4	Milky, yellow
L	White batiste	6.1	0.3	Milky, spotted
M	Treated glove material	11	4.3	Milky
N	White glove material	12	0.5	Milky, yellow

XII. ADDITIVES FOR FILM CLEANERS

Aside from the primary function of dirt removal, a film cleaner may be compounded to perform some secondary function which might otherwise require additional time and labor. Since these secondary purposes must not interfere with the cleaning operation itself, the materials that can be added to film cleaners are limited and additional care is necessary in the use of such modified cleaners.

Objectives

Control of static electrification and lubrication of film are the two features which can most successfully be obtained by the addition of nonvolatile materials to the cleaner.

Electrification control may be important for both raw and processed films to avoid the two most common consequences of electrification — latent image markings and dirt adhesion. The patterns on high-speed negative films from static discharges in the camera are familiar to most cinematographers and laboratory personnel and the tenacious adherence of dust and small dirt particles to a film which has accumulated a static charge is a common observation.

Electrification of motion-picture film results from two basic mechanisms: (1) charges are produced on the film surfaces by the contact of emulsion with base in the film roll; and (2) charges are built up by the travel of the film over rollers, film guides, etc. Both of these are unavoidable occurrences in most handling of motion-picture film.

Static discharge can be facilitated under some conditions by the deposition on the film of small amounts of certain hygroscopic, ionic-conducting materials, for example, by incorporation of such materials in the film cleaner. The most common materials are organic salts such as those of the quaternary amines, the sulfonates and others of this broad class. Their function is to increase the conductivity of the film surface and thus provide leakage paths for the dissipation of the static charges.

Inasmuch as such materials are conductive by virtue of their ionization, it should be noted that some water is required for them to become effective. Most frequently the materials used for static control are themselves hygroscopic and absorb small amounts of water from the air whenever the humidity is favorable, so that they operate in two ways to maintain an increased level of conductivity.

It should be noted, however, that film emulsion and base themselves contain small amounts of absorbed water (of the order of 1% to 2%) which comes into equilibrium with the normal moisture in the air surrounding the film — decreasing during exposure to dry air and increasing during exposure to moist air.[6]

Inasmuch as the film emulsion itself normally contains some conductive materials, the electrical resistivity of normal emulsion surfaces also decreases rapidly with increases in relative humidity as shown by curve E_0 in Fig. 7. There is normally, therefore, little difficulty with excessive electrification on films in equilibrium with air at 50 to 60% relative humidity. Since raw stock is packed by the manufacturer in a sealed container under these conditions, and since the larger commercial laboratories maintain the humidity of film-handling areas in this range by controlled air-conditioning, excessive static electrification is not normally a problem; however, difficulties tend to increase with the smaller commercial and semiprofessional users of film, who may not have the advantage of controlled air-conditioning for the maintenance of optimum humidity. Film handled in low-humidity areas will show greater electrification tendencies.

Unfortunately, since there is less moisture available for the ionization of antistatic additives under conditions of equilibrium with low-humidity air, their effectiveness also decreases, as shown in Fig. 7, by curves $E_1 - E_2$ for antistatic additives applied to the emulsion surface, and by curves $B_1 - B_2$ for antistatic additives applied to the support surface. Inasmuch as the resistivity of treated films usually remains below that of untreated films, however, such antistatic agents do offer some advantage for films which must necessarily be handled at low humidities.

Lubrication may also be provided during the film-cleaning operation through the incorporation of a soluble wax in the cleaning solvent, so that the application of such a cleaner deposits a tough, slippery coating over the entire film surface.¶ It was long ago noted[10,11] that this provides better film motion and a certain amount of protection from minor abrasion and other slight film damage.[12]

A proper lubricant applied to processed negatives is also advantageous; it aids the negative to assume precise positioning in the printer, and on continuous contact printers provides a steadier print.

Under some conditions, lubricants are applied only once during the life of a film. Especially in the lubrication of negatives, however, the subsequent frequent cleaning tends to remove the lubricant and reapplication may be necessary. Incorporation of the lubricant in the film-cleaning solvent is one practical method of handling this problem, since it is possible to design materials that will simultaneously clean objectionable dirt from the film and renew the desired lubricated surface.

Lubrication itself is a rather involved subject. Choice of a proper lubricant, its method of test and evaluation, and the proper use of the material are subjects to be discussed in a later paper.

Disadvantages

Whenever nonvolatile materials are added to a film cleaner it is possible that they will dry to a blushed or streaky surface, so that the primary objective of film cleaning is not realized. The streaking tendency of such materials depends upon their solubility characteristics in the particular solvent, and will therefore vary in different film cleaners. Acceptable materials must be evaluated under the conditions of their use in order to select those which will dry to a surface of good optical quality.

Materials to be used on processed negatives that are to be contact-printed have frequently shown sensitometric action by their transfer to the raw-stock print film. This has been a problem especially with antistatic additives, since most materials in this category show strong photographic activity. Some lubricating materials also show activity or, in more instances, interfere with the uniformity of the subsequent processing of the raw stock. Any contemplated additive which may have an opportunity to act upon a raw-stock emulsion should be tested for photographic activity by the same general procedures described under Section VI.

Finally, both lubricants and antistatic materials will reduce the adhesion of subsequently applied lacquers, magnetic stripes and other surface coatings.

¶Adequate lubrication for the projection of 16mm and 8mm films can be obtained by such an overall application of a wax solution to the film surface.[23] The projection of 35mm films, however, involves sufficiently greater forces and more severe projection conditions so that an overall lubrication must be supplemented by the application of additional wax along the perforation area. This is especially important for freshly processed prints.[24]

XIII. APPENDIX

Engineering for Safety in the Solvent-Cleaning of Motion-Picture Film

Solvent-cleaning facilities, because of their hazard through toxicity, flammability, or both, should be designed with care. Where any extensive operation is involved, the installations should also be checked after completion by actual analytic determination of vapor concentrations in every important area. Analytic services are available as noted in Section X.

The engineering design of installations is based upon relatively simple principles and premises which can be illustrated by several typical examples.

CASE I

Film cleaning is to be carried out as a hand operation in rather temporary quarters, so that general ventilation only can be provided. The operator will be exposed for most of an eight-hour day. Calculations are to be made for three cleaning solvents: carbon tetrachloride, methyl chloroform and hexane.

Basic Premises: Since general ventilation only will be provided, it will be necessary to dilute the solvent vapors at least to the maximum allowable concentration. There will be two operators in a room 8 ft by 10 ft by 8 ft high; the cleaning operation can be set up on a central table which gets a reasonable flow of air and does hot represent a stagnant pocket. Normal room temperature will be 75 F.

Measured Data: A controlled test of film cleaning was set up, using the same techniques, cleaning fabric, and solvent supply-can planned for the final operation. The following data were measured:

Solvent consumption — 120 ml/hr per operator. (This consumption was relatively independent of film speed, since most of the solvent was evaporated from the cloth rather than from the film. Losses from the container and from the application to the cloth were minimized by the use of spring-top pump-type dispenser cans. For these three solvents consumption was approximately the same in each case.)

Film speed — Variable, averaging 20 ft/min.

Available drying path — 3 ft.

Available drying time — 9 sec. All solvents did dry in this time.

Calculations: The determination of necessary air flows is outlined in Table VII. It will be noted that in the case of carbon tetrachloride, the required air flow of 1530 cu ft/min is a high rate for a room that contains only 640 cu ft! If the room were to be equipped with its own independent ventilating system, this air movement would require a large diameter centrifugal blower powered by a $\frac{1}{4}$-hp motor to handle this room only. The 75 cu ft/min required for methyl chloroform, and the 40 cu ft/min for hexane could be handled by an industrial-type ventilator — providing that adequate duct sizes and exhaust louvres are used in each case.

Note that hexane can be handled under these conditions only if its use is permitted by the local fire code, and only if additional precautions are taken. Not only must smoking be forbidden anywhere in the vicinity, but also all open flames must be avoided, electrical equipment in the film-cleaning area must be vaporproof, metallic equipment should be grounded, and the stock supply of cleaning solvent must be isolated and stored in a safe area.

Note also that these calculations assume the vapors are uniformly and rapidly mixed in with the whole air supply. *If this mixing does not take place, then these volumes may be insufficient to provide safe working conditions.* Obviously if the room ventilation by-passes the work area, then the concentration of vapors may exceed the maximum allowable concentration for personnel safety, or may come so close to the lower explosive limit as to be excessively hazardous in these portions of the room.

Table VII. Calculation of Ventilating and Exhaust Air: CASE I, Cleaning Bench With General Room Exhaust Only.

	A	B	C
1. Cleaning solvent	Carbon tetrachloride	Methyl chloroform	Hexane
2. Max. allowable conc.	25 ppm	500 ppm	500 ppm
3. Lower explosive limit	—	—	1.2%
4. Max. design conc.			
A. Personnel	0.0025%	0.05%	0.05%*
B. Equipment	—	—	0.3%
5. Solvent vaporized			
A. ml/min	4.0	4.0	4.0
B. Liquid density	1.60	1.32	0.660
C. g/min	6.40	5.28	2.64
D. Molecular weight	154	133	86.2
E. cu ft/min at 75 F†	0.0382	0.0365	0.0282
6. Air flow to dilute,‡ cu ft/min	1530	73.0	56.4
7. Ventilation for comfort,§ cu ft/min	40	40	40
8. Design air flow, cu ft/min	1530	75	60
9. Grille area, total‖			
A. Inlet, sq in.	625	75	75
B. Exhaust, sq in.	1250	150	150

* The Physiological Limit is less than the Equipment Limit (25% of the Lower Explosive Limit) and therefore, design is based upon the Physiological Limit.

† Gram molar volume at 75 F = 0.920 cu ft.

‡ Based upon levels established by max. design conc.

§ 20 cu ft/min per person minimum.

‖ Free area estimated at 65% of total area.

CASE II

Film cleaning is to be carried out under the same conditions as Case I, except that a permanent installation is planned, with local exhaust ventilation directly at the cleaning area.

Basic Premises: Since local exhaust is provided, the ventilation design will be based upon an adequate capture velocity at the point of vapor production, so that the solvent vapors will be drawn into the exhaust duct and carried safely away. We assume the same two operators working at a centrally located table, in a room of the same size. The same three solvents will be checked.

The cleaning table is assumed to be constructed as shown in Fig. 6 where the two exhaust grilles are arranged to discharge into a common exhaust duct. The "baffling" around the grille is significant, as will be discussed later.

Measured Data: Same as Case I.

Calculations: The determination of necessary air flows is outlined in Table VIII. Note that the calculations for step 6 are based upon *only one cleaning station,* but that at step 7 the air-flow requirements are doubled to take care of the second operator — it is this value which should be compared with Case I.

The basis of this calculation is the approximate relationship[2]

$$Q = \frac{V}{4}(10X^2 + A)$$

where

Q = volume of air exhausted, cu ft/min.

V = capture velocity at a distance X from the grille and on the axis of symmetry,

X = distance of cleaning area from grille, ft, and

A = area of grille, sq ft.

The divisor 4 is introduced because, as shown in Fig. 6, the grille is baffled both horizontally and vertically to restrict the directions from which air can be drawn into the exhaust. This relationship is

Table VIII. Calculation of Exhaust Air: CASE II, Cleaning Bench With Local Exhaust, as Shown in Fig. 6.

	A	B	C
1. Cleaning solvent	Carbon tetrachloride	Methyl chloroform	Hexane
2. Max. allowable conc.	25 ppm	500 ppm	500 ppm
3. Lower explosive limit	—	—	1.2%
4. Max. design conc.			
A. Personnel*	0.0025%	0.05%	0.05%
B. Equipment†	—	—	0.3%†
5. Solvent vaporized			
A. ml/min	4.0	4.0	4.0
C. g/min	6.40	5.28	2.64
E. cu ft/min at 75 F	0.0382	0.0365	0.0282
6. Calculation of capture Conditions for 1 grille			
A. Capture velocity, ft/min	100	100	100
B. Distance from grille, ft	0.5	0.5	0.5
C. Air exhausted (Q), cu ft/min‡	88	88	88
7. Application to 2 grilles			
A. Total air exhaust, cu ft/min	176	176	176
8. Solvent vapor conc. within duct	0.0217%§	0.0207%	0.0160%‖

* Effective limit for personnel must be observed, but in this example significant vapor concentrations are obtained only within the duct, and in the area immediately in front of the grille — thus, outside of "breathing space."

† This limit cannot be exceeded in the ducts without risk of explosion.

‡ Based upon design equation, $Q = V/4\,(10X^2 + A)$. See text.

§ This value is acceptable since there is no personnel exposure to air with this high solvent concentration.

‖ This value is acceptable since it is below the Max. Design Conc. for Equipment.

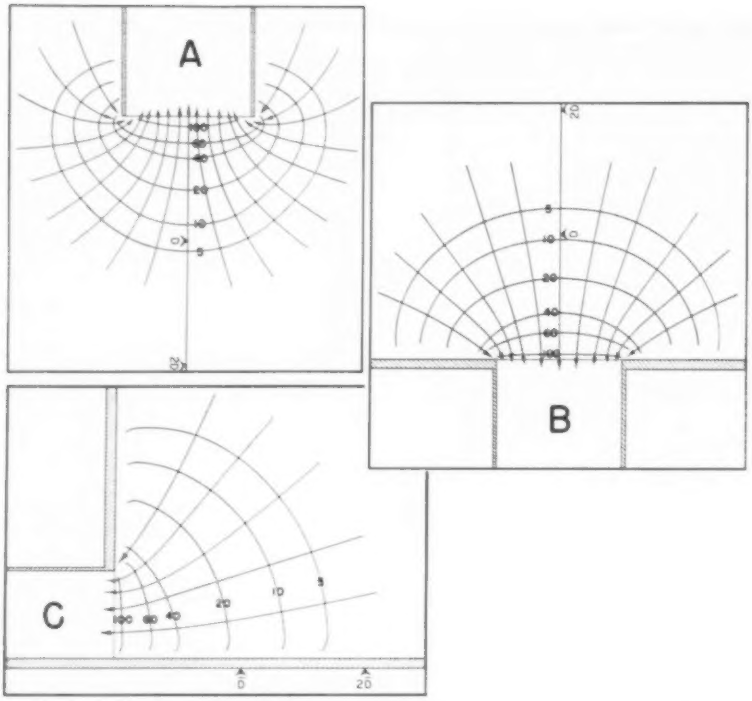

Fig. 9. Air velocities and flow lines about various baffled grilles.[4] Velocity contours are labeled in percent of velocity at grille face. Installation A is an unbaffled exhaust duct; installation B, a grille set into a plane-baffle of large area, such as a table top; installation C, a grille set into the intersection of two large plane-baffles of large area, such as the joining of a "bang-board" with a table top. For simplicity in representing velocity contours, grilles A and B are circular, grille C is semicircular with the same total area as grilles A and B. Designations D and 2D locate points whose distance from the grille face is equal to 1 and 2 times the grille diameter, respectively (for grille C, $\bar{D}$ is the diameter of a circular grille having the same area as the semicircle C).

shown diagrammatically in Fig. 9.

In this calculation there are several points worthy of comment:

(1) If the exhaust grille had been located horizontally on the table top between the two cleaning stations, then the divisor in the equation for determining Q would have been 2 instead of 4, requiring twice the air flow for the same capture velocity. However, the grille would now have served both stations, so the total air required would remain the same. Actually such a design would be inconvenient in its operation because the two cleaning stations would be too close together for ease in operation.

(2) If the exhaust grille had been located 1 ft away from the cleaning point instead of 0.5 ft, the necessary air flow for the same capture velocity would have been *four times* as great. This emphasizes the need in local exhaust designs for locating the grille as close to the work area as possible.

(3) The area of the grille is less important than its location in determining the flow, and therefore the grille can easily be made large enough to provide ventilation for the solvent supply-can and a place for temporary "storage" of the solvent-wet cleaning cloth.

(4) Note that the nature of the solvent is not important in this calculation, and that the degree of dilution in the exhaust duct is not of primary importance. Carbon tetrachloride, under these conditions, will exist inside the exhaust duct in concentrations well above the maximum allowable limit. This is not important *provided the exhaust is properly directed outside the building, away from all personnel, and discharged in such a way as to mix thoroughly with large volumes of the outside air*. For flammable solvents, it is still necessary that the concentration inside the ducts be lower than the explosive limit; in this calculation the air flow is more than adequate. The capture-velocity design has the further advantage of insuring good mixing of the vapors with air and minimizing the danger of local pockets of high vapor concentration.

(5) This amount of air flow in the room is more than adequate for comfort, so that the ventilating system need only be adequate to replace this amount of exhaust (without requiring excessive pressure drop in the exhaust duct).

The choice between a Case I installation and a Case II installation will many times be made on the basis of cost and expediency. On the merits of the solutions themselves, however, Case II is to be preferred because it offers greater security for the operators and better protection from exposure to local pockets of high vapor concentration, *provided that all the sources of solvent vapors have been identified and each has been provided with a proper local exhaust.*

CASE III

A motorized film-cleaning machine is to be totally enclosed, and a suitable cabinet exhaust provided. Determine the necessary ventilation for the use of methyl chloroform.

Basic Premises: The machine will be designed as indicated in Fig. 10. It will be operated continuously, with film supply and take-up located outside the main enclosure to avoid subjecting the operator to the high vapor concentrations in the cleaning and drying sections.

Measured Data: From a preliminary trial of the apparatus operated with temporary ventilation, the following data were determined:

Film speed — 150 ft/min.
Solvent consumption — approximately 300 ml/hr.
Available drying path — 50 ft.
Available drying time — 20 sec.
Air temperature in drying section — 85 F.
Air temperature in room — 75 F.

Calculations: The determination of necessary air exhausts from the cleaning cabinet is outlined in Table IX. Note that the pressure inside the cabinet is chosen to be less than that in the room in order to minimize the tendency for solvent vapors to diffuse out into the work area.

First new step in the calculations is to determine the values to be used for 7A and 8A, in Table IX. Preferably, the vacuum squeegee has its air requirements determined by test; the door leakage into the cabinet can be calculated, once the pressure within the cabinet is established, by the use of known empirical correlations.[2] With these known values, several operating conditions become possible — conditions X and Y are listed in Table IX by way of examples.

Condition X represents the minimum possible air flow, since leakage air only is supplied to the cabinet. This would represent tolerable operation when the machine is totally enclosed; concentrations in the supply and take-up cabinets would probably be low, but the machine would need to be designed so that the central cabinets did not need to be opened during normal operation.

Condition Y represents an air flow that, after mixing, reduces the solvent-vapor level to the maximum permissible for personnel exposure. This would provide very desirable operating conditions, permitting the central cabinets to be opened when necessary to correct threading, adjust cleaning plush, etc.

Table IX. Calculation of Cabinet Ventilation: CASE III, Totally Enclosed Cleaning Machine, Fig. 10.

1. Cleaning solvent		*Methyl chloroform*
2. Max. allowable conc.		500 ppm
3. Lower explosive limit		—
4. Maximum design conc.		
A. Personnel		0.05%
B. Equipment		*
5. Solvent vaporized		
A. ml/min		5.0
C. g/min		6.60
E. cu ft/min		0.0456
6. Design pressure inside cabinet, in. of water		−0.1†
Operating Condition:	*X*	*Y*
7. Air exhaust		
A. Vacuum squeegee, cu ft/min	3.0	3.0
B. Main exhaust, cu ft/min	29	88
8. Air inlet		
A. Door leakage,‡ cu ft/min	32	32
B. Additional air supply, cu ft/min	0	59
9. Solvent vapor concn. within machine	0.143%§	0.05%‖

* In the absence of explosive hazard, the solvent vapor level *inside* the cabinet can be chosen with considerable freedom.
† Chosen to insure air leakage into the cabinet, in order to avoid escape of solvent vapor.
‡ Calculated.[8]
§ This concentration is acceptable for total enclosure. The cabinet is so designed as to minimize solvent vapor in the supply and take-up sections, so that vapor does not escape into the room when the operator is changing rolls. If this condition is not met, then the machine concentration may not be safe.
‖ This concentration would be acceptable for personnel exposure.

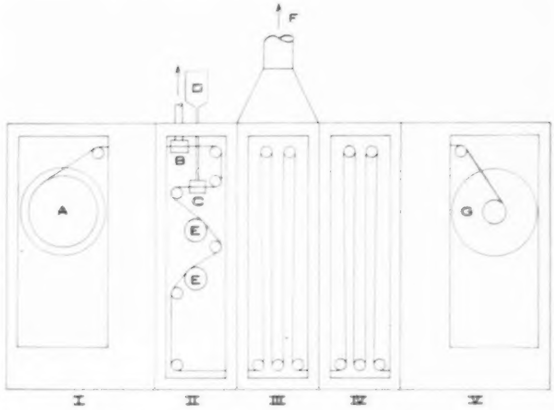

Fig. 10. Typical totally enclosed film-cleaning machine. Overall dimensions are approximately 9 ft, by 4 ft 4 in., by 1 ft. Lettered designations are as follows:

A, film supply and elevator;
B, vacuum-cleaning squeegee;
C, solvent-plush cleaning station;
D, solvent supply;
E, buffing rolls;
F, main air exhaust;
G, film take-up and elevator.

Necessary air supply in addition to that provided by leakage into the cabinets from the room is admitted through the bottoms of cabinets I and V.

It should be noted that since room air is drawn into the cleaning machine, it is necessary to control dirt within the entire room even though the cabinet is enclosed.

Acknowledgment

In the preparation of this paper the authors have had advice and assistance from the Manufacturing and Engineering Divisions, the Research Laboratories, and the Medical Divisions of the Eastman Kodak Company; we are indebted to many of our colleagues for information presented in this paper and for advice on its preparation. We wish to acknowledge also the assistance of the Motion Picture Film Department for their help in correlating laboratory objectives with trade usage.

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Prolonging the Life of Motion-Picture Release Prints

By ERIC C. JOHNSON

Hundreds of release prints are discarded annually because of needless damage to the film. This fact has received renewed emphasis with the increased use of film in television. Proper film handling procedures and techniques are described, starting with the "green" print and the need for film lubrication, then on through projection, cleaning and inspection.

Millions of dollars are spent yearly in producing theatrical, nontheatrical, and television shows on film. Good screen image quality is essential for effective presentation. It is axiomatic that everything possible should be done to maintain release prints in good condition. It should never be necessary to withdraw a print from circulation because of unnecessary damage nor should it be necessary to exhibit a damaged print.

It is likely that a considerable amount of film is discarded not because the film itself is worn out but because of accidental damage caused by improper handling techniques or inadequate attention to equipment maintenance.

This fact has become particularly noticeable in television studios where the life expectancy of a print is substantially less than it is in theaters. The life of much of the film used on TV is limited by the timeliness of the subject matter or, as in the case of kinescope recordings, by contract commitments; however, other types of program such as feature films and syndicated shows are under no such limitations and have a viewing potential limited only by the demand for the show. Theoretically much of the film used in television should have, at the least, the life expectancy of a theatrical print.

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(This paper was received on March 18, 1958.)

Much has been written on the handling of release prints and a thorough treatment of the subject would fill a good sized book. There are certain aspects, however, which bear repeating and these are outlined briefly.

Whether we consider a 16mm release print for TV or a 35mm release print for theater use, the handling practices are fundamentally the same and the observance of good technique can lengthen the life of all types of film. Good technique should extend to all aspects of film handling; however, the following areas are considered more critical than others, and particular attention to proper handling methods in these areas will produce significant improvement in film performance.

Lubricating the Print

Print life starts from the moment the print emerges from the processing machine. At this point, the print is frequently referred to as a "green" print, although it exhibits no unusual characteristics from a visual standpoint. From a performance standpoint, however, such freshly processed prints may give difficulties when projected. Under certain circumstances, particularly under conditions of high relative humidity, the freshly processed emulsion may accumulate on the warm gate unless the print has been lubricated. As a result, the film may stick in the projector gate and be distorted by the high pulldown forces so that the projected image will become unsteady. At its worst, the film can seize-up in the gate and become permanently damaged. After a print has been subjected to the heat of projection a few times, it will become less critical in this characteristic.

Green-print sticking can be prevented by lubricating the print before projection.[1,2,3] This is a simple process which consists essentially of applying a dilute wax solution to the surface of film. Several formulas are available for good lubricating solutions.[1,2,4] A solution which gives acceptable results consists of 0.1 g of a wax such as Hercules P-E Tetrastearate in 100 ml of a solvent such as Chlorothene.* Solutions of this type can be applied by hand or with one of the several mechanical applicators commercially available.

The effectiveness of film lubrication can be illustrated by comparing the frictional force required to pull lubricated and unlubricated film through a projector gate. Two such measurements for 16mm film are shown in Fig. 1. These were obtained by measuring the force required to pull a length of film through a simulated projector gate at a constant speed.[3] Correlation of measurements made in this manner with results obtained from actual projection tests show that frictional forces greater than 6 oz may cause gate sticking during projection.

When lubricating by hand, a simple and efficient procedure can be used which sandwiches the film between two lintless cloths as shown in Fig. 2. As the film is run through the cloths, a light pressure on the top cloth maintains contact with the film surface. The cloths should be frequently rewet with the lubricating solution because of the high evaporation rate of the solvent. Because of this solvent evaporation, it is important to maintain adequate ventilation in the surrounding working area. A typical mechanical device suitable for this purpose is shown in Fig. 3. Figure 4 shows an applicator at the end of a 16mm processing machine. It is most important, whether lubricating by machine or by hand, that the cloth surface which contacts the film be changed constantly. If this is not done, dirt particles quickly accumulate and abrade the film.

It is advisable to choose the cleaning cloth carefully. The best cloths for the purpose are clean, short-nap rayon plush or velvet. These have the advantage of holding the accumulated dirt away from

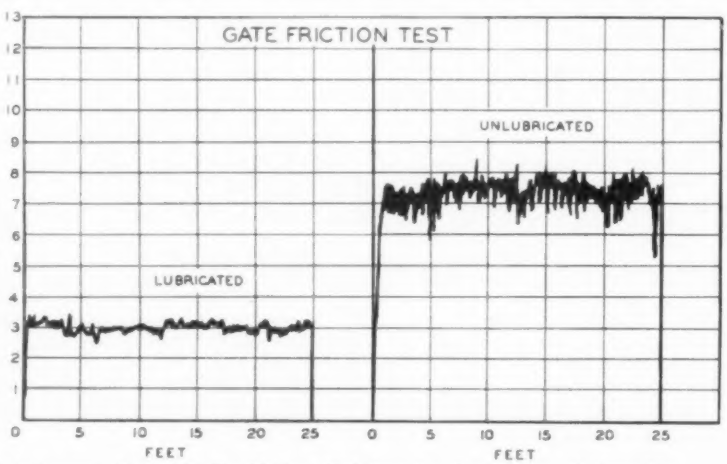

Fig. 1. A comparison of the film friction of lubricated and unlubricated 16mm film.

* A trade name of Dow Chemical Co.

Fig. 2. Hand application of lubricating and cleaning solutions.

Fig. 3. A typical mechanical device for lubricating and cleaning motion-picture film.

the film surfaces for a longer period than other types.

The speed at which the film is wound through the cloth is determined by the rate of evaporation of the solvent from the surface of the film. The film should not be wound into the roll while wet.

Cleaning the Print

A release print which has accumulated dirt on its surfaces should be cleaned as soon as possible not only to obtain better screen image quality but also to avoid irreparable damage to the print.

The techniques and precautions to be used when cleaning a print are identical to those described above for print lubrication. The solutions recommended as being good lubricants are also good cleaners. There are also certain machines and methods available, such as the detergent-water cleaning method, which involve specialized procedures. When cleaning a print, even though it has long since passed the green stage, it is advisable to use a cleaning solution which contains a lubricant. Should a method of cleaning be used which does not incorporate a lubricant, it is wise to relubricate the print after cleaning. The performance of the film in the projector will be improved and the susceptibility to scratching in the gate will be considerably reduced.

Release prints should not be cleaned by wiping with dry cloth. Such practice results only in removal of loose surface dirt and is not recommended because of the increased susceptibility to scratching.

Fig. 4. A wax applicator at the end of a 16mm processing machine.

Projector Cleanliness

When a projector has been in service for a short time it is not unusual to find a deposit of emulsion on the contact areas of the gate. This emulsion deposit will build up at a very rapid rate, particularly if a few unlubricated prints are projected. It is most important to keep the gate area clean. An effective way to remove this emulsion deposit is with a wooden scraping tool similar to the orange stick commonly used by manicurists (Figs. 5 and 6). After scraping the emulsion from the guide rails, the remaining deposit can usually be removed with a soft cloth dampened with water. In cleaning the gate, it is important not to use a hard scraping tool which can mar the highly polished surface. A gate which is scratched or burred will severely damage a print and should be repaired or replaced immediately.

The projector gate is probably the most critical part of a projector as far as potential film damage is concerned and when a projector is in continuous use the gate should be cleaned at least once a day. Frequently, however, the rollers in the film path can also cause damage. Unless these rollers are maintained in a free-turning condition, the film can be scratched as it passes over the rollers. On the other hand, excessive oiling of projector parts can result in a residual oil deposit on rollers and film contact areas. This oil is transferred to the film and a mottled picture will result (Fig. 7).

Inspecting the Print

More potential hazards to print life exist during the routine handling of the print on the inspection bench than in any other phase of its existence. The most common reason for removing a print from service is abrasion; therefore, in all phases of print handling, cleanliness should be a primary concern. This is particularly true in areas where film is rewound, inspected, spliced, etc. Particles of dirt on the film can act like cutting tools if permitted to rub across the film surface. At least once a day, all working areas including work tables should be vacuum cleaned; cigarette ashes, dirty gloves, open windows permitting the entry of airborne dirt, etc., can take a heavy toll in print life.

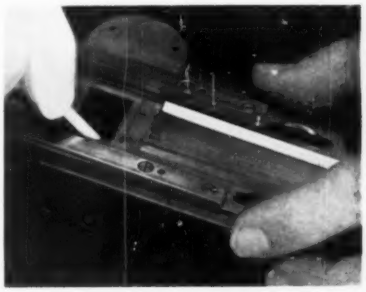

Fig. 5. Removing emulsion deposit from guide rails of a 35mm projector gate.

Fig. 6. Removing emulsion deposit from guide rails of a 16mm projector gate.

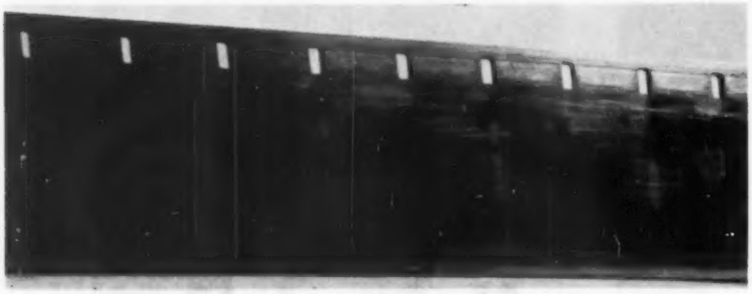

Fig. 7. **Oil mottle on film.**

Fig. 8. Holding film during inspection.

In handling a print which is even slightly dirty, a few simple rules should be followed in order to prevent unnecessary film abrasion. For instance, while inspecting a print, the film should be held by the edges between the thumb and forefinger as shown in Fig. 8. By holding the film in this manner any dirt which is on the film will not accumulate under the fingers. Furthermore, holding the film in this manner is an efficient way to detect splices which are beginning to part and perforations which have become damaged. White gloves make the procedure a safer one in that oily finger marks resulting from the handling of the film during handling and inspection are eliminated but the gloves must be laundered and changed frequently or they quickly lose their advantage. Whether wearing white gloves or not, one should never grasp the film in such a manner that the picture area is pulled through the fingers.

Damage is frequently caused by merely rewinding the film from one reel to another. A bent reel or one having burred sides may damage the edge of the film and make the print more vulnerable to tears. A check should be made of the rewind mechanisms to be sure that they are in exact alignment and reels in disrepair should be discarded. A bad reel can quickly cause damage to film many times more costly than the reel's replacement value.

When rewinding a print, the object is to produce a snug smooth roll. The only way this can be accomplished is by rewinding the film at a steady rate while maintaining a slight tension on the supply reel. An erratic, jerky rewind action is the source of the short cinch marks of the type seen in Fig. 9. These marks are caused by the slipping of one convolution of the roll over another, usually when a piece of dirt is trapped between the film. A particularly bad technique is to wind the film at a very high speed and then permit it to coast. The film which coasts on to the takeup reel is usually loose. These loose convolutions will slip over one another when increased tension is applied to bring the film up to its original speed.

It is important that a tight roll be produced on the rewind. When a loose, sloppy roll similar to that shown in Fig. 10 is handled in subsequent operations, dirt and dust particles can easily work their way into the film. For this reason and for the general protection of the reel and film, the print should always be shipped in a can.

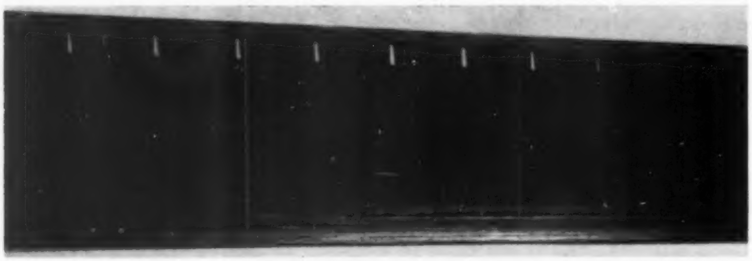

Fig. 9. Cinch marks.

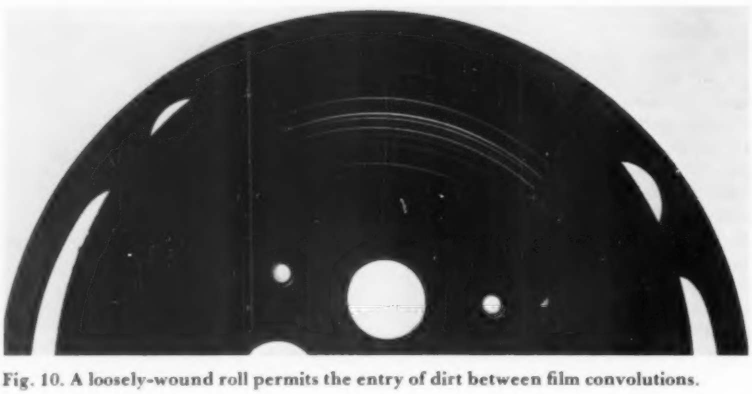

Fig. 10. A loosely-wound roll permits the entry of dirt between film convolutions.

Conclusion

It is reasonable to expect that a motion-picture release print can withstand several hundred projections before the film is actually so worn that it must be discarded. With proper care, as outlined above, a print should give, throughout its useful life, screen image quality indistinguishable from that produced by a new print.

A 22-min 16mm sound color motion picture entitled *Murder on the Screen*, was shown at the conclusion of this paper. This was produced for the Eastman Kodak Company for the special purpose of showing the possible causes of damage to prints and proper methods of handling to prevent such damage as described in the paper.

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A New Series of Lenses for Vidicon-Type Cameras

By JOHN D. HAYES

The continued growth of the vidicon type of television pickup camera in both the industrial and studio broadcast fields has precipitated the development of a new series of lenses intended particularly to fulfill the requirements imposed by this type of camera. These lenses have been optically and mechanically designed to provide a high degree of illumination as well as an excellent aberrational correction and level of performance throughout the entire receptor area.

THE USE by the vidicon camera manufacturer of the American Standards Association 16mm camera mounting thread, 1.000 in. by 32 threads/in., and a flange focal distance of 0.690 in.[1] has made it possible to mount lenses intended for the so-called C-mount 16mm camera onto the vidicon camera. The exchange of lenses between photographic and television applications is a highly desirable condition; however, several differences exist between the requirements of the photographic 16mm camera and the television vidicon camera which must be considered before such an exchange is made. Among these differences are the increased size of the vidicon format with respect to the 16mm camera format, the differences in the spectral sensitivity of the vidicon tube and the photographic emulsion, and the introduction into the optical system of the glass tube face.

The 16mm camera lens has been designed and corrected for a format size of 0.410 in. by 0.294 in. (0.505 in. diagonal). The vidicon format requires a correction for a coverage of 0.500 in. by 0.375 in. (0.620 in. diagonal). This increased coverage required by the vidicon equipment is more than can be satisfactorily accommodated by many 16mm camera lenses, particularly those of shorter focal length. Additionally, it is customary in the mechanical design of an optical instrument such as a photographic lens to provide sunshades and other light-baffling devices to limit the field of view to that required by the intended application. Thus, when a 25mm lens intended for the required 16mm camera coverage of about 28° is used on the vidicon camera requiring a coverage of nearly 35°, it is not unexpected that a lack of illumination may be noted in the outer field areas as well as a serious degradation of performance.

Although differences in the color correction of lenses intended for use on the vidicon pickup tube and with present-day photographic emulsions are small, their consideration in a completely integrated design must be included. Similarly, the optical effects of the thin (approximately 0.090-in.) glass tube face separating the phosphor surface (focal plane of the lens) and the lens must be included in the design parameters.

In consideration of the importance of these differences between the requirements of the photographic 16mm camera and the vidicon camera, Bausch & Lomb has designed a series of lenses intended primarily for vidicon applications. A list of these lenses is given in Table I. Additional goals set, and met, for these lenses were: no lens to have less than 50% relative illumination at any point in the vidicon format; all lenses to have a minimum back focal length of $\frac{9}{16}$ in. to permit mounting onto turret model cameras; and each lens to be of small overall dimensions and inexpensive design.

The desire to develop a series of lenses with at least half as much light in the corners of the format as on axis (50% relative illumination) at maximum aperture imposed rather severe design limitations with regard to lens types. For example, some 50mm $f/4.5$ vidicon lenses provide no more than 45% relative illumination at the format corners. Typical 50mm T/2.5 lenses used on orthicon equipment have about 35% relative illumination, whereas some 35mm T/2.3 lenses on the standard motion-picture format provide 10%. There is no general rule for determining the minimum number of elements necessary for producing a high-quality optical system.[2] It was necessary, therefore, to consider each lens individually and to develop the required formula rather than develop a single formula, and derive the required focal lengths therefrom.

Table I. Lenses for Vidicon-Type Cameras.

Lens f.l., mm	f/No.	Coverage* Horiz.	Vert.	Diag.	Rel. Illum.**
15	2.5	46	35.3	55.3	53
25	2.5	28	21.3	34.5	50
35	2.5	20.5	15.5	25.3	72
50	2.5	14.3	10.8	17.3	81
20	3.5	35	26.8	43	55
25	3.5	28	21.3	34.5	57
35	3.5	20.5	15.5	25.3	63
50	3.5	14.3	10.8	17.3	80
75	3.5	9.5	7.3	11	65
100	3.5	7.3	5.3	9	70

*Based on the vidicon format of 0.500 in. by 0.375 in.

** % at format corners.

The 15mm $f/2.5$ lens of this series is of the reversed telephoto type, T-d of the Kingslake classification.[3] This type of construction is characterized by a high degree of relative illumination, wide angular coverage and a back focal length equal to, or greater than, the equivalent focal length making it an ideal choice for this particular focal length. The split-front triplet construction was used for the 25mm $f/2.5$ and with variations for the 75mm and 100mm $f/3.5$ lenses, type K-a. The 35mm and 50mm $f/2.5$ lenses are of the five-element type, Figs. 1–4. Because of the modest focal length, speed and coverage of the 25mm, 35mm, and 50 mm $f/3.5$ lenses, it was possible to obtain a high degree of performance from the well-known triplet type of construction, type G; however, the somewhat larger angular coverage of the 20mm lens necessitated the use of a four-element air-spaced design for this $f/3.5$ lens, type J-b.

The excellence of the correction of these various lenses is indicated by representative test data obtained from tests upon electronic evaluation equipment similar to that described by Edgar Hutto of RCA.[4] This type of test equipment consists of a rotary scanning drum target, a photomultiplier pickup and an oscilloscope. The square-wave flux-pattern target is imaged by the lens under test, the aerial image thus formed is magnified by a microscope, analyzed by the photomultiplier and presented on the oscilloscope as an average square-wave response vs. line number. Figure 5 presents the test data obtained from the 15mm $f/2.5$ lens. It is to be observed that high average square-wave response has been obtained out to and beyond 700 television lines both on axis and through a field angle including some two-thirds of the total field. Even at the full field angle of about 55°, a most favorable performance is indicated.

A similar presentation of data, Fig. 6, is made for the lens at the other extreme of the focal range, the 100mm $f/3.5$ lens. Here again, an extremely high

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Jan. 7, 1958 J. D. HAYES ET AL 2,818,776

OBJECTIVE LENS

Filed Jan. 16, 1956

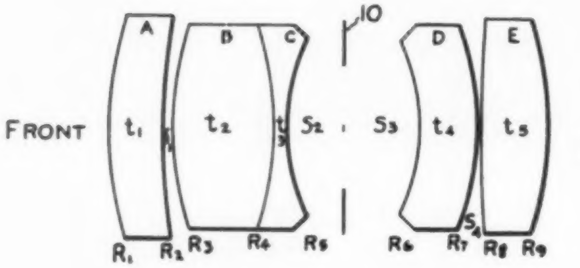

FIG. 1

	E.F.=100	f/2.3	F.A.= 56°	
LENS	RADII	t AND S	n_D	V
A	R_1=46.80 R_2=136.38	t_1=6.33 S_1=1.0	1.670	47.2
B	R_3=41.76 R_4=-226.0	t_2=11.14 t_3=3.16	1.657	50.9
C	R_5=24.95	S_2=9.3	1.668	32.3
D	R_6=-25.27 R_7=-35.89	S_3=7.52 t_4=9.26	1.649	33.8
E	R_8=985.84 R_9=-52.05	S_4=.08 t_5=8.11	1.620	60.3

FIG. 2

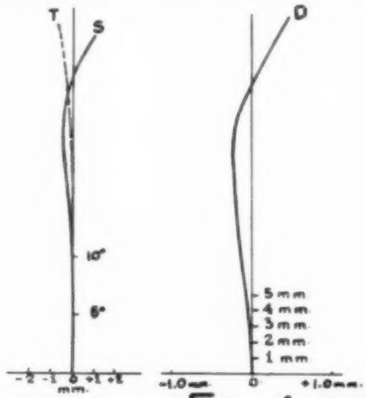

FIG. 3 FIG. 4

INVENTOR.
JOHN D. HAYES
AND
LENA M. HUDSON
BY
ATTORNEY

Figs. 1–4. Basic form of the 35mm and 50mm f/2.5 lenses.

response is observed to a point well beyond the reproduction capabilities of the vidicon tubes in use today, generally of the 500- to 600-line range. Of particular note is the uniformity of performance of this lens over the entire tube-face area. This lens, as well as the 75mm $f/3.5$ lens, has been designed to utilize only those gamma radiation insensitive optical glasses[5] developed especially for use in radiation areas.

Although these various lenses have been designed for use on the vidicon pickup camera, their excellence on the 16mm camera is not to be overlooked. In those instances where a direct focal-length comparison with the standard military 16mm gun camera series could be made, namely, 25mm, 35mm, 50mm and 75mm, photographic tests have been made in accordance with the applicable MIL specifications.[6] In all instances, these lenses were found to yield photographic resolution values equal to or in excess of the military requirement. It should be pointed out that these lenses are not mechanically compatible with the military requirements nor are the military speed requirements duplicated by these lenses.

Among the variety of applications of vidicon pickup systems, some are ideally suited for fixed-focus lenses, whereas others require focusable lenses. One of the primary criteria for the determination of the mounting of the lens is the depth-of-field considerations. Although a great deal of work has been done and material published regarding depth of field, the most acceptable criterion is that based upon the basic optical principles of the cone angle in the image space, that is, the f-number of the lens, as translated into a circle of confusion.[7]

The data presented in Table II have been prepared on the basis of a circle of confusion of 0.0010 in., which is the customary value for critical work with lenses of this type. For simplification, all lenses have been assumed to be focused upon an object at 15 ft. From this it is noted that both the 15mm and 20mm lenses, when focused at an object distance of 15 ft, show a depth of field of from nearly 7 ft to nearly infinity. For this reason, both lenses are mounted in fixed-focus mounts. On the other hand, all other focal lengths are available in one speed or the other in either a fixed or a focusing mount, and the 50mm, 75mm and 100mm $f/3.5$ lenses are available in either type of mount.

An additional criterion for the selection of a lens for a particular application is its field coverage. Also listed in Table II is the field coverage of these lenses at a distance of 15 ft with a vidicon receptor area of 0.500 in. by 0.375 in. From these data, application engineers can immediately find a multitude of uses for lenses of this focal range such as are found industrially in plant and product surveillance, super markets, traffic controls,

Table II. Mount and Coverage Characteristics.

Lens f.l., mm	Mount type	Depth of Field, ft[c] Near	Depth of Field, ft[c] Far	Field Size, ft[d] Horiz.	Field Size, ft[d] Vert.
$f/2.5$					
15	FF[a]	7	Infinity	12.8	9.5
25	Foc.[b]	11	28	7.5	5.6
35	Foc.	12	19.5	5.5	4.1
50	Foc.	13.5	17	3.8	2.9
$f/3.5$					
20	FF	7.5	530	9.5	7.1
25	FF	9	40	7.5	5.6
35	FF	11.5	22.5	5.4	4.1
50	FF and Foc.	13	18	3.8	2.9
75	FF and Foc.	14	16	2.5	1.9
100	FF and Foc.	14.5	15.5	1.9	1.4

(a) Fixed focus; (b) focusing; (c) based upon an object distance of 15 ft and a circle of confusion of 0.001 in; (d) based upon an object distance of 15 ft and a format size of 0.500 in. by 0.375 in.

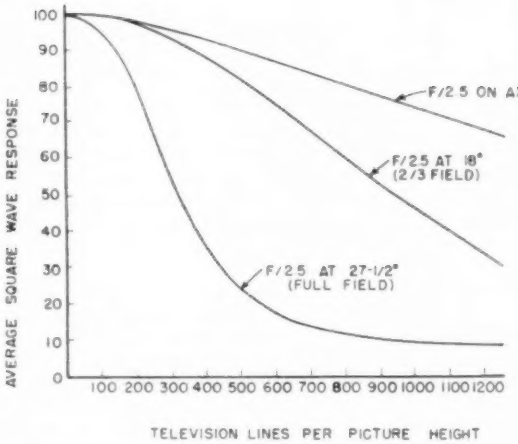

Fig. 5. Performance characteristics of 15mm f/2.5 lens.

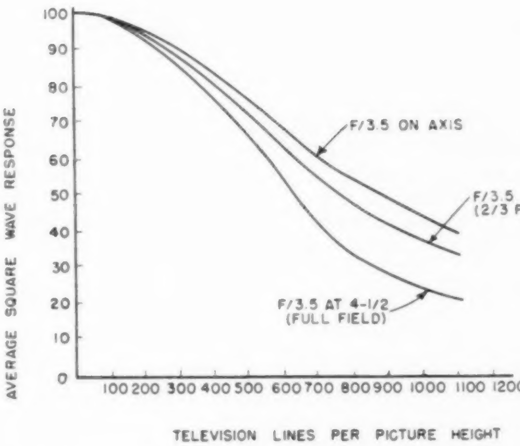

Fig. 6. Performance characteristics of 100mm f/3.5 lens.

harbors, airports, etc., not to mention the entire studio and broadcast fields.

All of these lenses, shown in Fig. 7, are C-mount lenses. Their appropriate mechanical parts are made of aluminum. The *f*/2.5 series has been color coded blue, whereas the *f*/3.5 series has been color coded red thus permitting easy identification. The iris-diaphragm actuating ring of each lens rotates in a clockwise direction for "stopping down" and operates to *f*/22.

The focusing range of the focusing mounted lenses is from infinity to 1 ft for the 25mm *f*/2.5 lens, 2 ft for the 35mm *f*/2.5 and 50mm *f*/3.5 lenses, 2½ ft for the 50mm *f*/2.5 lens, and 3 ft for the 75mm and 100mm *f*/3.5 lenses. These near distances were chosen so as to provide for an image reduction of about twelve times. With the overrun of the focusing scale provided on the near-distance end and by repositioning of the vidicon tube, somewhat nearer focusing can be accomplished. It is believed that these lenses will fill a long-needed requirement of the rapidly expanding industrial and studio vidicon reproduction fields for a highly corrected series of lenses of a variety of focal lengths of sufficient speed to afford adequate pick-up, yet of inexpensive optical and mechanical design.

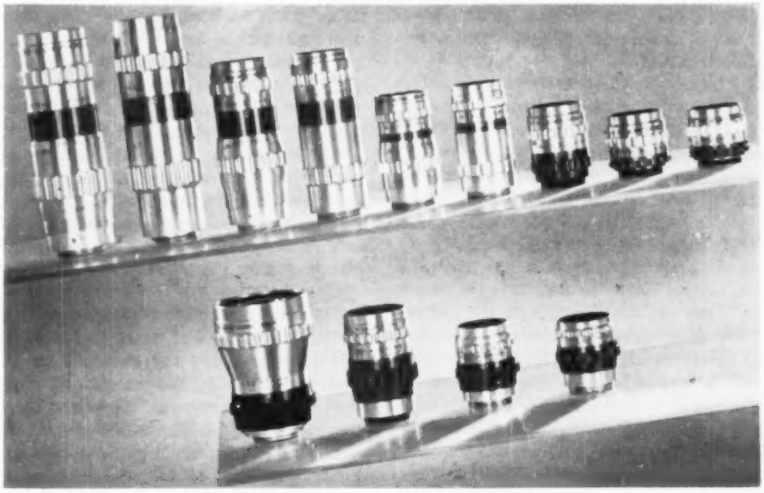

Fig. 7. Top row — f/3.5 lenses, left to right: 100mm focusing, 100mm fixed focus, 75mm focusing, 75mm fixed focus, 50mm focusing, 50mm fixed focus, 35mm fixed focus, 25mm fixed focus, 20mm fixed focus. **Bottom row — f/2.5 lenses, left to right:** 15mm fixed focus, 50mm focusing, 35mm focusing, 25mm focusing.

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Vidicon Camera Lenses

By GORDON HENRY COOK

Lenses intended for use on vidicon-type TV cameras must have wide relative aperture and uniformity of illumination throughout the picture area and must yield the type of performance demanded by TV transmission channels. The picture format is larger than that utilized in 16mm film cameras and the aberrational effects of the tube end glass thickness are perceptible. The paper discusses the suitability of standard cinematographic lenses under these conditions of use and describes a new range of lenses designed specifically for this purpose.

THE REQUIREMENTS for a lens to be used in television are of special nature because of the limited bandwidth available in a television channel. Ideally, a lens should have a frequency response curve which is both high and uniform from zero frequency out to a frequency corresponding to the number of picture elements contained in one television picture line. Schade[1] has published a detailed description of these special requirements.

The British 405-line system is capable of transmitting 490 picture elements along each line and, in the case of the vidicon picture format of 13 by $9\frac{1}{2}$ mm, this corresponds to a limiting pattern frequency of 19 patterns/mm (one line pattern considered as a line and a space). The United States 525-line system contains 427 picture elements per line corresponding to a limiting frequency of 17 patterns/mm. In the latter system there is an increased number of picture elements in the vertical direction but this is less important optically due to the inherent limitations of line picture scanning. In the assessment of lens performance that follows, a limiting frequency of 20 patterns/mm is considered a reasonable value for both systems.

Although the vidicon-type tube can offer certain electronic and dimensional advantages over the image orthicon, some consideration must be given to the ability of the lens manufacturer to solve new and more severe optical problems if comparable standards of performance are to be achieved.

These new problems are concerned with the need for much higher levels of image illumination throughout the picture format while maintaining the same response or modulation at higher pattern frequencies in the image.

The specification of the new lenses developed for this purpose is based on the linear scaling factor of 2.5 between the sizes of the vidicon and image orthicon picture formats. The same factor converts inches to centimeters, so that a lens of X cm focal length on vidicon cameras covers the same angular field of view as a lens of X in. focal length on image orthicon. If the centimeter range has relative apertures increased 2.5 times, it is capable of yielding 2.5^2 or about 6 times as much image illumination and it will have the same depth of field as the inch range. Thus a 3-cm $f/1.4$ vidicon lens is optically equivalent to a 3-in. $f/3.5$ image orthicon lens provided it yields the same response at pattern frequencies increased by 2.5 and if the vidicon tube is not less than one-sixth as sensitive as the image orthicon. The assumption that $f/3.5$ lenses are essential for some applications of image orthicon lenses is not necessarily true, so greater differences in sensitivity can probably be accommodated.

The image formed by the lens lies on the inside glass surface of the tube end and, since this thickness of glass introduces detectable amounts of all optical aberrations, it must be included in the computation and measurement of lens performance. Within the limiting pattern frequencies occurring in television the effects of the aberrations so introduced are negligible when the angular field of view is small and at narrow relative apertures.

At the wide relative apertures necessary for vidicon use, these effects are not negligible. Figure 1 indicates the computed performance with a postulated perfect lens with no aberrations forming its image through a glass plate 0.093 in. thick. The graph plots percentage modulation to sine waves at 20 patterns/mm at a relative aperture of $f/1.4$ against the semiangular field of view. For an axial image point the response drops to only about 95% but modulation decreases very rapidly with increasing angular field and becomes significantly worse beyond 5°. The perfect lens has been given an arbitrary amount of vignetting across the field and, since vignetting is equivalent to a reduction of the relative aperture of oblique beams, the effects of plate aberrations are reduced. This partly accounts for the flattening of the curve at the wider angular field positions.

The curve refers only to image boundaries which are tangential with respect to the lens axis because the aberrations introduced by the glass thickness of the tube end affect these more severely than boundaries radial to the axis. All the lenses to be discussed later yield a response on radial images which is equal to or slightly better than that on tangential images, and, for the sake of simplicity, values for the latter only will be given.

If the lens had all its residual aberrations of exactly the same magnitude and opposite sign to those introduced by the tube end, a modulation of nearly 100% would be obtained throughout the field of view. Needless to say, such a lens is as impracticable from the design point of view as the perfect lens.

In practice, lenses fall short of perfection and have appreciable residuals of all the optical aberrations. The effects of the tube end are never quite so obvious, partly because the degradation of a poor image is less detectable, and partly because some of the large residual aberrations in the lens may happen to be of opposite sign to the smaller additional aberrations of the tube end and thus a small degree of compensation could fortuitously occur.

What may be concluded, however, is that the better the performance of the lens alone the more necessary it becomes to introduce into its design compensation for the aberrations of the tube end. At wide relative apertures and useful fields of view, an argument that the effects of the tube end need not be incorporated into its design can be taken as an admission that the lens under consideration has a poor performance.

In the past, the computation of frequency response would have been a long and tedious matter, but the use of an electronic computer in conjunction with a new method of computing response functions implicitly from the actual aberrations present in the lens now permits a rapid and accurate assessment of lens performance at the design stage. The new method, which will be published later, yields results

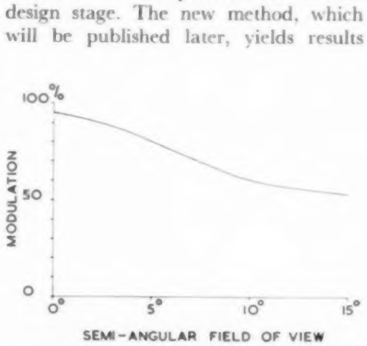

Fig. 1. Sine-wave response: 3-cm f/1.4 perfect lens; frequency, 20 patterns/mm — effect of tube end.

Presented on April 25, 1958, at the Society's Convention in Los Angeles by Gordon Henry Cook, Taylor, Taylor and Hobson, Ltd., Stoughton St., Leicester, England.
(This paper was received on March 13, 1958.)

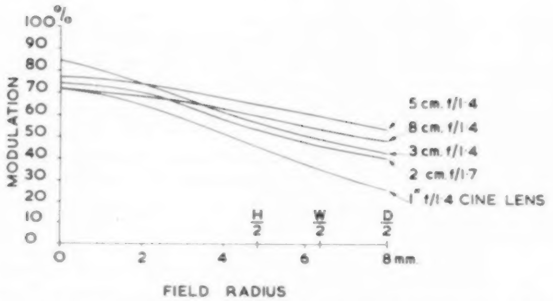

Fig. 2. Sine-wave response: frequency, 20 patterns/mm; full perture through glass tube end.

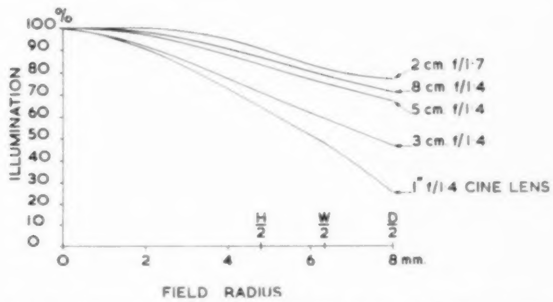

Fig. 3. Percentage vignetting relative to axial illumination — at full aperture.

in very close agreement with those determined experimentally by a photoelectric lens testing method which, in principle, follows suggestions made by Lindberg.[2]

16mm Cine Lenses

Lenses designed for use on 16mm film cameras are intended to cover a picture format of $10\frac{1}{2}$ by $7\frac{1}{2}$ mm — an area about 60% of the vidicon area. It may be expected, therefore, that when such lenses are used on vidicon TV cameras there will be a more pronounced deterioration of both sharpness and uniformity of image illumination towards the periphery of the larger format.

Although the resolving power of the best of these lenses in the true photographic sense is greatly in excess of the capacity of any known television channel, attempts are rarely made to improve their response characteristics at the lower levels of resolution which can be transmitted. In fact, computational and experimental evidence shows that there are special aberrational requirements in television lenses which differ from those in photographic lenses. If these can be fulfilled, the transmitted image information will be more sharply defined and modulated more accurately to reproduce the true contrast levels of the original object.

A range of lenses has been developed specifically for use on vidicon-type cameras. The design of each lens takes full advantage of recent advances in the art and makes good use of new optical materials. Although the lenses will perform excellently as film camera lenses their prime purpose is television and they have been corrected accordingly. Each lens is named Vidital and, at present, the range comprises four lenses: 2-cm $f/1.7$, 3-cm $f/1.4$, 5-cm $f/1.4$ and 8-cm. $f/1.4$.

Figure 2 shows the results of photoelectric tests on these four lenses and also on a 1-in. $f/1.4$ 16mm cine lens which for a number of years has earned a good reputation as a quality lens and which may be considered as an average example of the better lenses generally available.

The graphs refer to tests at the limiting frequency of 20 patterns/mm with the lenses set at maximum relative aperture and with glass thickness of the tube end in position. The points D/2, W/2 and H/2 on the semidiagonal ordinate correspond respectively to the corner of the format, center sides and center top and bottom.

Figure 3 shows the variation of image illumination produced by the same lenses at maximum aperture. Axial illumination is taken as 100% in all cases and the graphs plot the percentage reduction along the semidiagonal of the format. The curve for the 1-in. cine lens emphasizes its inability to cover adequately a picture format larger than the one for which it was designed.

The curve for the 2-cm $f/1.7$ Vidital is also of special interest because the adoption of a new type of inverted telephoto lens construction has made it possible to reduce its degree of vignetting to a very unusual level. In spite of its slightly narrower relative aperture of $f/1.7$ it can transmit as much total illumination over the whole picture area as other lenses in the range at $f/1.4$.

Figures 4 and 5 show the optical construction of the 2- and 3-cm Vidital lenses. The 5- and 8-cm Viditals are of the same general shape as the 3-cm but with minor dimensional modifications. These modifications arise from the fact that each lens is designed specially to cover its own angular field at the highest possible level of performance. Direct scaling of construction from one focal length to another does not yield the desired result since the consequent scaling up of aberration is too severe.

Overall Assessment of Performance

The curves shown in Figs. 2 and 3 are of course not the only criterion of performance. The limiting frequency is only one of many frequencies which are important and the lenses have to provide the highest possible response at a variety of relative apertures. For example, the aberrations of these lenses could be modified fairly easily to yield even higher responses at full aperture at the expense of performance at other narrower apertures.

The full assessment of the performance of a TV camera lens may be expressed in the form of several sets of similar curves. These should describe the response of the lens to a range of pattern frequencies at various relative apertures and at various points in the field of view. Different orientations of the test pattern are necessary to determine lens response at image boundaries radial and tangential with respect to the lens axis.

Many curves of this nature are difficult to assess and attempts have been made to define performance by a single figure of merit which can deal adequately with all the factors involved. A method

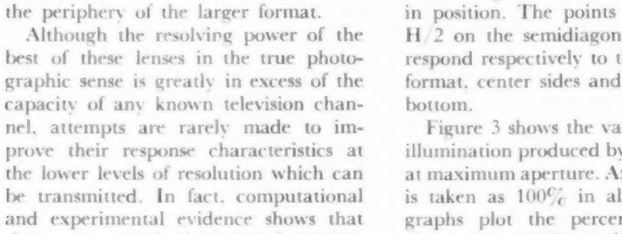

Fig. 4. 2-cm f/1.7 Vidital.

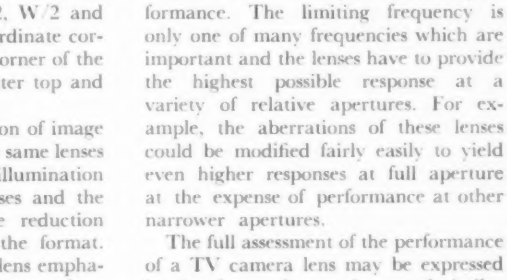

Fig. 5. 3-cm f/1.4 Vidital.

has been proposed by Sproson[3] which gives satisfactory agreement with observed television results.

Liminal Units

This method describes performance at each relative aperture by a single figure expressed in liminal units. A liminal unit, as defined by the British Broadcasting Corp., is a measure of subjective sharpness. A difference in rating of one unit implies that when lenses are compared on television channels of full information carrying capacity 50% of the observers can perceive a change and 50% are unaware that a change has been effected. Thus, if a perfect lens is rated at zero limital units, a lens rated at less than one unit can be regarded as producing negligible picture degradation.

This subjective sharpness factor at a single field position may be determined by integrating the response at that point from zero frequency up to the cutoff frequency of the television system. A change of subjective sharpness of 1 liminal unit is produced when the integrated response is reduced from 1 to 0.89. In most cases this will correspond to slightly less than 0.8 modulation at the limiting frequency.

Table I. Overall Assessment in Liminal Units.

Lens	Relative aperture	Sharpness	Vignetting	Total
2-cm. $f/1.7$	$f/1.7$	−1.9	0	−1.9
Vidital	$f/2.8$	−0.9	0	−0.9
3-cm. $f/1.4$	$f/1.4$	−1.7	−0.6	−2.3
Vidital	$f/2.0$	−0.9	0	−0.9
	$f/2.8$	−0.7	0	−0.7
5-cm $f/1.4$	$f/1.4$	−1.5	0	−1.5
Vidital	$f/2.0$	−0.5	0	−0.5
	$f/2.8$	−0.5	0	−0.5
8-cm $f/1.4$	$f/1.4$	−1.6	0	−1.6
Vidital	$f/2.0$	−1.2	0	−1.2
	$f/2.8$	−0.7	0	−0.7
1 in. $f/1.4$	$f/1.4$	−2.2	−1.3	−3.5
Cine Lens	$f/2.0$	−1.4	−0.9	−2.3

Having found the sharpness factor in this way for a number of points in the field of view, the overall factor for the whole picture area can be integrated with respect to a field which is weighted according to the picture area corresponding to each angular field position and which has a further supplementary weighting giving the central areas a higher "interest" value than the periphery.

An overall factor for the vignetting characteristics of the lens may be determined in a similar manner. The overall assessment of lens performance at any relative aperture is the sum of the factors for subjective sharpness and vignetting.

Expressed in these terms the lenses under discussion may be rated according to the values shown in Table I.

These results show quite clearly that careful attention to new design procedures can yield lenses with excellent television characteristics and which, when used at one stop below maximum aperture, are almost indistinguishable from the perfect lens.

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Acknowledgments

The author wishes to thank his colleagues, W. S. Blaschke, for assistance in preparing computing programs; J. Littler, for laboratory measurements. Thanks are also due Taylor, Taylor & Hobson Ltd. for permission to publish this paper.

Zoom Lenses for Closed-Circuit Television

By FRANK G. BACK

In the rapidly growing field of closed-circuit TV, zoom lenses are becoming increasingly important. A number of zoom lenses are now available. The different characteristics of these lenses are described, their advantages and disadvantages discussed and their functions explained.

Closed-circuit TV may be described as off-air video transmission. The frequent use of the term "industrial television" to describe closed-circuit TV is misleading as it limits it to only one of its many applications. In closed-circuit transmission, orthicon equipment can be used but vidicon chains are more frequently used. Many problems are present in broadcast TV, such as problems connected with programming and switching, which do not affect closed-circuit TV. On the other hand, in situations where one person controls the entire operation and is at the same time observer, director, cameraman and the engineer monitoring the remotely controlled camera, other problems of a technical nature are apt to arise. Choice of equipment is important. The increasing use of zoom lenses in closed-circuit TV indicates the desirability of a study of these lenses in respect to characteristics and proper use.

Zoom lenses are not high-speed lenses and should not be used where low light levels are expected. The elimination of a turret in favor of a remotely controlled continuing variation in picture size has obvious advantages, but a picture of good quality but the wrong size is preferable to a picture of the right size but poor quality caused by lack of light. Zoom lenses, if properly employed, will give satisfactory results provided the right type of zoom lens is chosen for the job.

In order to choose the right type of lens, familiarity with the properties and characteristics of zoom lenses in general, especially characteristics which do not exist in single-focal lenses, is required. Zoom lens characteristics include focal-length limits, zoom range, variable picture quality, f-speed, physical dimensions, weight, vibration and noise characteristics.

Focal-Length Limits and Zoom Range

A single-focus lens has only one focal length while a zoom lens has a whole focal-length range and cannot only zoom (make an object appear to come closer or move away) but can substitute for any lens within that particular focal-length range. The range of the zoom lens is, therefore, of great importance; and the longer the zoom range, the more single lerses may be replaced by one single zoom lens. Zoom lenses are available with more than one zoom range. These lenses are very versatile. At present, the smallest zoom range available on closed-circuit TV zoom lenses is 3:1; the largest, 6:1. The application indicates which zoom lens should be chosen. It should be noted

Presented on April 21, 1958, at the Society's Convention in Los Angeles by Frank G. Back, Zoomar, Inc., Glen Cove, L.I., N.Y.
(This paper was received on August 22, 1958.)

that the coverage grows with the square of the zoom range. A 3:1 zoom range will cover, in its wide-angle position, 9 times as much as in its telephoto position; and a zoom lens with a 6:1 range will cover 36 times the area in its wide-angle position as it covers in its telephoto position.

Picture Quality

Picture quality is measured, in many cases, by resolution lines. Resolution lines are a combination of the optical resolving power of the lens and the electrical resolution of the TV camera. These are difficult to separate, so to determine which portion is camera and which is lens is a pretty tricky laboratory procedure.

On a single-purpose lens, resolution can be determined by checking a test target which fills the entire screen, and determining the resolution, for example, in the center and on the edge of the frame. On a zoom lens, the resolution target is varied while going through the zoom range (always filling the whole frame). The average resolution over the entire zoom range is determined separately for center and edge in order to do justice to the lens. Usually the different zoom positions do not give equal picture quality. There may be some positions which are just as good as in the best single-focus lens and some positions which are not. Recently great strides have been made in lens design due to the electronic computing machines used in optical calculations and also to considerable insight into the theory of zoom lenses in general. All these things in connection with the end use of the lens should be taken into consideration.

F Speed

Most closed-circuit TV lenses do not vary the speed during the zoom, and the *f*-number reading holds through the entire range. Some lenses, however, change speed when open in the telephoto position, and this may impair the use of the lens.

It has been noted above that zoom lenses are not high-speed lenses, and an *f*-number around *f*/3 is considered a fast zoom lens. If very long focal-length zoom lenses are employed, the *f*-number goes down considerably, and those lenses should be used only under the best light conditions.

In keeping with the trend toward reducing the bulk and weight of cameras, amplifiers, transmitters and other photographic equipment, zoom lenses have been made smaller. A reduction in size necessitates higher precision of components, resulting in economical and efficient operation. These accomplishments are reflected in the data given in Table I.

Mechanical Noise (Motor-Noise Level)

If the movable parts are made with great accuracy and with antifriction devices, driving motors can be reduced in size and the speed reduced without getting close to the critical minimum torque requirements. This, of course, is only possible if d-c motors are employed. A-c motors, run at low speed, will have an unduly high pole number and such motors would be very big if they were made for running at low speed. D-c motors with permanent magnets can be run at very low speed if the load is small and if measures are taken to prevent voltage drop in starting. On the other hand, these reversible d-c motors require only one wire plus a common ground connection, which permits cables that are much lighter and less expensive. This is especially important when the distance between zoom lens and control box increases. The combination of precision gear design with antifriction devices, nonmetallic gears and low-speed high-torque starting d-c motors reduce mechanical noise on zoom lenses to the minimum.

Table I. Comparison of Available Zoom Lenses for Closed-Circuit TV Cameras, Spring, 1958.

Lens type	Focal length, mm	Zoom range	TV-Resolution Lines Center	TV-Resolution Lines Edge	*f*/no.	Transmission variation	Approx. Dim., in. H	W	L	Weight, lb.	Motor noise level
Pan Cinor 60	20–60	3:1	300	250	2.8	None	3	3	4	2	Manual
Pan Cinor 70	17.5–70	4:1	600	400	2.4	None	3	3	6	2	Manual
Zoomar 16	25–75	3:1	500	400	2.8	None	2	2	5	1.5	Manual
Pan Cinor 100	25–100	4:1	600	400	3.4	None	3	3	7	2	Manual
Kintel-Zoomar	25–75	3:1	500	400	2.8	None	2	2	5	4.5	Noisy
Diamond Power-Zoomar	25–75	3:1	500	400	2.8	None	2	2	5	4	Noisy
Hallomar-Zoomar	20–120	6:1	350	300	4.0	None	2	2	7	1.5	Noisy
Pan Cinor 60 Motorized	20–60	3:1	300	250	2.8	None	4	4	5	7	Noisy
Pan Cinor 100 Motorized	25–100	4:1	600	400	3.4	None	5	5	7	6	Noisy
Auto-Zoom 16A TV S	30–150	5:1	600	250	3.5	±50%	6	6	8	6.5	Noisy
Auto-Zoom 16A TV L	60–300	5:1	500	250	7.0	±50%	6	6	8	7	Noisy
ITV-Zoomar Mark II S	22–130	6:1	500	400	3.5	None	3	3	6	2.5	Low noise
ITV-Zoomar Mark II L	35–210	6:1	500	400	5.6	None	3	3	6	2.5	Low noise

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Discussion

Frank N. Gillette (General Precision Laboratory): In speaking of the characteristics of zoom lenses, particularly resolution, why do you find it necessary to strike an average? Wouldn't it be more meaningful if it were expressed as a curve, resolution versus focal length?

Dr. Back: This would be very complicated. It would have to be done step by step, from inch to inch, and the resolution would have to be shown from different parts of the frame, from center to edge. One curve could not do it and a family of curves, to people not very familiar with the subject, would be confusing rather than enlightening.

Zoom lenses usually have three or four positions where the resolution is perfect and com-

parable with the resolution of single-focus lenses. In other positions, the resolution is slightly worse, and there are even a few positions where a noticeable change in picture quality can be observed, as compared with a single-purpose lens.

This decrease in picture quality occurs sometimes only in the middle of the frame, and in some positions only toward the edge. Therefore, the best and simplest method of describing the picture quality is by measuring the quality over the entire frame and averaging it out.

Dr. Gillette: This handicaps a user who may wish a zoom lens primarily for operation in the region where it is at its best. He will not be able to determine, from your figures, the maximum performance of which it is capable, because you will have degraded your actual measurement by averaging over the poor region.

Dr. Back: This is true, to an extent only, because the variations are not too big. If I say, for instance, there is a resolution of 500 lines, on one hand counted, by standard television practice, over the entire frame, and if on the other hand, we would take a differential count over a part of the frame, we might find sections with 500, sections with 600, and sections with 450 television lines over the same frame.

If, for instance, a poor edge resolution exists in one particular position, and we make sure that this shortcoming is not electronic, it can mean different things: it can mean astigmatism of the lens, it can mean (strange as it may sound for a black-and-white picture) a color aberration, or it could mean an oblique spherical condition or a field curvature. Here again, looking at three-dimensional subjects, such a field curvature might look, if curved in the proper direction, like a remarkable depth of field. Therefore, for the average user not versed in the technique of testing photographic optics, the figures given in the table are very practical.

Dr. Gillette: I'll ask one more, which is perhaps unfair: You stated that the performance of zoom lenses is now getting pretty close to the performance of fixed-focus lenses. Would you care to define that more closely, say, in terms of contrast ratio at 200 lines or something of that sort? Give the ratio of contrast of a zoom lens to that of a fixed focal length lens of equal focal length and equal aperture.

Dr. Back: It is much better to say something about the general design of zoom lenses. Zoom lenses need more elements than fixed focal length lenses for the same aperture and for the same angle. For instance, if we build a good zoom lens for a 6:1 ratio and *f*-speed of 3.5, we have to use ten lens elements. A single-purpose lens with an *f*/3.5 aperture needs only three or four elements. The difference between the internal reflection of a 4-element lens versus a 10-element lens will be exactly the glare difference or contrast difference between an *f*/3.5 zoom lens and an *f*/3.5 single-purpose lens.

Since the reflection on high refractive glass today can be reduced by coating to 1% per surface, the contrast difference between a zoom lens and a single-purpose lens is, today, smaller than the contrast difference between a coated and uncoated lens of the same design. As I stated, repeatedly, before, most of the people today take resolution lines as the only characteristic for lens performance. I have seen lenses on test give fantastic results when checked against test patterns. These lenses, however, on actual photographic tests, produced poor picture quality. I have seen lenses with substandard resolving power when tested with test targets still give excellent picture quality in practical use. The question is, therefore, well put when you ask about contrast tests on zoom lenses.

Contrast, resolution, absorption, and color response are integral properties of any lens and all must be taken into consideration if you are evaluating lens performance.

A Direct-Drive Automatic Iris Control

By MERVIN W. LA RUE, JR., JOHN P. BAGBY, STEPHEN F. BUSHMAN, STANLEY R. FREELAND and DAVID M. MACMILLIN

A new type of automatic iris control is incorporated in the Bell & Howell Design 290 8mm camera. The iris control is operated solely by power from a photovoltaic cell, made feasible by the exceptionally low power requirements of a unique rotary "barn-door" iris. The method of construction results in a highly shock-resistant mechanism with an almost unlimited service life. The automatic control is described and some of the design considerations discussed.

The logical processes involved in the development of new and better ways of doing things can be of considerable interest. The development of the automatic iris control in the Bell & Howell Design 290 camera had certain unusual aspects. Because of its special interest the reasoning which led to the developmental work on the Design 290 will be described in connection with a description of the camera.

Many years ago, our company recognized the potential value of a motion-picture camera which would set its own lens iris to obtain proper film exposure. The first result of the effort in this direction was the development of a battery-powered automatic iris control. This automatic iris control was placed on a 16mm magazine camera* and later, on a 16mm spool camera.

Unfortunately the conventionally petite 8mm motion-picture camera would not tolerate the bulk and weight necessitated bv the battery-powered exposure control. At first the problems seemed great but, during continuing effort to devise an automatic iris control suitable for a smaller camera, it was noted that some of the requirements for such a camera were basically different from requirements for a 16mm camera. First, the lens aperture diameters were considerably smaller because of the shorter lens focal length, so an equivalent lens iris configuration could be expected to require much less power. Second, the control was intended for use with a single frame speed camera in which almost all of the film used has an exposure index of either ASA 10 or ASA 16. This materially reduced the range of exposure conditions to be provided for.

In view of the lowered power requirements, bulk reduction could have been obtained by miniaturing the existing system, but even more desirable would be the elimination of components. Of the four primary components in the 16mm system, elimination of the motor and batteries appeared to present the fewest problems. We thus proceeded on the assumption that a system could be constructed using only a photocell and meter as the primary components. This left only two choices; either an alternate power source must be found, or the power requirements of the iris must be greatly reduced.

Obtaining an alternate power source appeared more reasonable at first because of the proximity of the camera spring motor. This appeared even more reasonable when it was found that the alternative would require a reduction to perhaps one-millionth of the usual power requirements. In spite of its apparent lack of promise, study of the power reduction approach was also continued.

Four separate schemes were proposed whereby an electrical meter would suitably regulate power from the camera mainspring. All were workable, but each was found to have some limitation. One scheme, for example, would not cause the iris to reach its setting until several frames had been run, and could be "primed" only by an inconvenient manipulation of the iris ring. Another required the rather precise balancing of several springs, and had possibilities of being a difficult production item.

Several proposals for utilizing the power reduction approach had also been presented. In general, these proposals involved novel variable apertures with sufficiently low frictional torque to allow them to be driven by some type of

Presented on April 21, 1958, at the Society's Convention in Los Angeles by Mervin W. La Rue, Jr. (who read the paper), John P. Bagby, Stephen F. Bushman, Stanley R. Freeland and David M. MacMillin, Bell & Howell Co., 7100 McCormick Rd., Chicago 45.
(This paper was received on March 17, 1958.)

* Mervin W. La Rue, Jr., "A new automatic iris control for motion-picture cameras," *Jour. SMPTE, 66:* 413–416, July 1957.

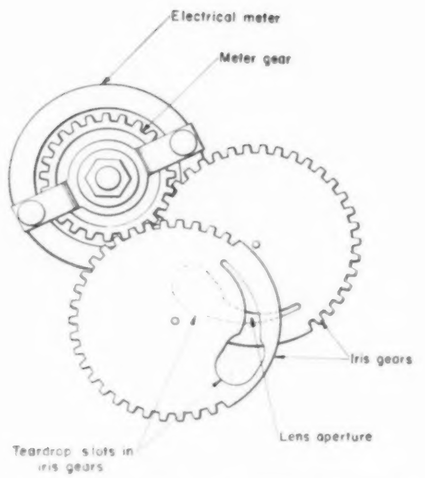
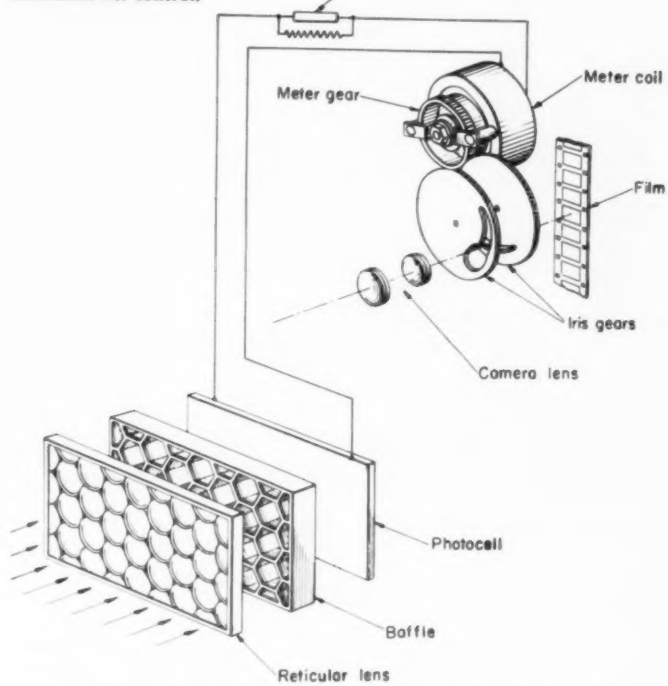


Fig. 1. Mechanical schematic of meter-driven iris.

Fig. 2. Schematic of direct-drive automatic iris control.



connection to the meter. Many such ideas had been considered in the past but were generally abandoned because power requirements were too great or because they were too sensitive to external movement. However, one of the arrangements now proposed did not appear to have such faults.

As shown in Fig. 1, this proposed mechanism used two overlapping disks, each of which carried a wedge-shaped annular slot with the intersection of the two slots forming a variable aperture. These disks were to be supported on conical jeweled pivots to obtain the lowest frictional torque which could be envisioned. Gear teeth were formed on the periphery of the disks, and these were engaged with a gear which was mounted on a meter coil and which rotated with it. By using a single meter this promised to avoid excessive expense; but, more important, was the effect of externally applied forces on the system. The conventional construction of an electrical meter results in momentary changes in its coil position as a result of rotational accelerations, and the performance of an automatic iris would be seriously degraded if its setting were influenced by minor movements of the camera. As can be seen in Fig. 1, the rotational inertia of the two iris disks has been arranged to oppose that of the meter armature, with the very desirable result that the effect of externally applied rotational movements can be eliminated. When operation of several models confirmed these characteristics, this proposal was selected for production design.

Initial Design Problems

With the basic form of the automatic control established (Fig. 2), three problems required solution before a detailed layout could be completed. First, a method of altering the response of the system (biasing) was required to match the two film sensitivities. Second, a very obvious indicator must be provided to inform the user whenever the light level fell below the point where the maximum lens opening was sufficient for proper exposure. Third, it should be conveniently possible to disengage the automatic control and manually set the iris to any desired fixed opening. A fourth problem, ever present in camera design, was that of fitting all of this mechanism into the smallest possible space.

Biasing

The small difference in emulsion speed between the two films indicated that biasing could be conveniently accomplished by masking of the photocell. A design advantage of this method is that the iris response characteristics are unaltered by the biasing. The system thus need only be designed to respond properly for the highest emulsion speed to be used. Lower emulsion speeds are then accommodated simply by a proportionate reduction in the active area of the photocell. The mask evolved into a simple metal slide, with a ball and spring detent to retain it in either of the positions provided for the two emulsion speeds.

Underexposure Indicator

The principal limitation in providing an underexposure indicator was that there was no appreciable surplus of power to operate it. Several solutions were proposed. The solution which was selected (Fig. 3) employs a long, slender prism to "pipe" light from the iris indicator window into the viewfinder. A flag attached to the pointer of the meter covers the front end of this prism when the meter approaches its zero position; thus, the viewfinder end of the prism appears bright whenever there is sufficient light for photography and appears dark when there is not. A further nicety was added by coloring the indicator amber to increase its apparent visibility. It might be mentioned that the use of an indicator which became light, rather than dark, at the low light level was considered. This was felt to be undesirable, inasmuch as at light levels considerably below the minimum the indicator might again appear dark, thus giving a false indication that sufficient light was available.

Manual Control

Since a single frame release was provided on the camera, there existed the possibility of its being used for special effects. It is also occasionally desirable to override the control purposely, especially in scenes with strong backlighting or abnormal contrast. In such cases the latitude of the film is not sufficient to reproduce properly the entire range of scene brightnesses, and exposures can be improved by purposely exposing only for the brightness of the object of interest. These considerations made the provision of a positive manual control desirable if the camera were to remain as flexible as a nonautomatic camera.

The most satisfactory manual control arrangement was one in which rotation of an external knob short-circuits the

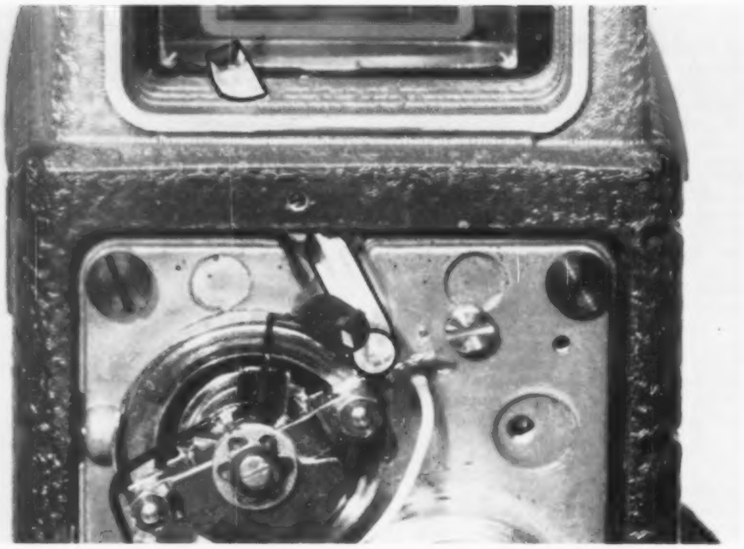


Fig. 3. Underexposure indicator.

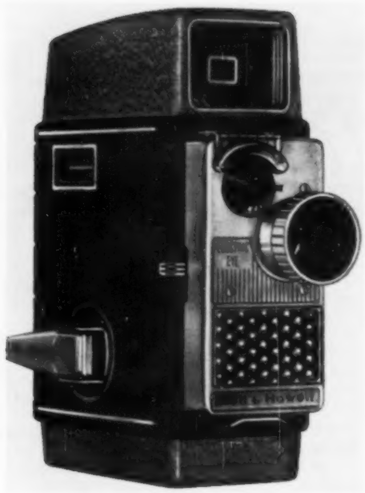


Fig. 4. Bell & Howell Design 290 8mm camera.

meter, causing the meter coil to "collapse" to its zero (lens wide open) position. Further rotation of the knob then causes an arm to engage and rotate the meter coil, carrying the iris disks to any desired position. The actual iris opening is indicated by a pointer, attached to the meter coil, which is visible through a kidney shaped window at the front of the camera.

Basic Engineering

As in the 16mm system which preceded this one, the engineering of this system required the optimizing of several mutually interdependent variables. Factors of most importance were acceptance angle, photocell size and resistance loading, meter sensitivity and torque, temperature sensitivity, and accuracy. The general approach is described below.

The choice of acceptance angle was simplified by the generally satisfactory performance of the 16mm system, and was allowed to remain the same. With the acceptance angle having been selected and the maximum size of the photocell known as the result of space and styling restrictions, the output vs. resistance loading characteristics of the photocell were determined.

Selection of the optimum photocell loading required consideration of meter sensitivity, magnitude of photocell temperature compensation necessary, and the effect of all of these upon meter torque. With the meter doing all of the physical work in the system its torque output was of considerable importance. While preliminary calculations indicated that the expected torque was sufficient to overcome friction, there would be no appreciable surplus. The deflection sensitivity of the meter was also limited, since too small a deflection per *f*-stop would require a larger and heavier meter gear to obtain the same angular iris movement, and could also cause the space limitations imposed by the camera to be exceeded. A study of these and other factors led to a photocell loading of 6000 ohms, and a meter deflection sensitivity of $2°/\mu a$. It is interesting to note that optimum power transfer from the photocell to the load is obtained in the neighborhood of 9000 ohms, but at the same time a larger proportion of the load must then consist of unproductive temperature compensation.

With the photocell loading having been determined, an assignment of resistance between meter coil, temperature compensator and trimming resistor (to compensate for variations between photocells) was the next step. The intent, of course, is to minimize power losses by assigning as much of the total resistance as possible to the meter coil. In this design it was very effectively proposed that a series of thermistor-resistor pairs be used. Each pair in this series would have the same temperature compensation characteristics but a different total resistance, thus making it possible for the thermistor-resistor pairs also to fulfill the function of trimming. The elimination of the trimming resistor by this means made it possible to retain approximately three-fourths of the total external resistance in the meter coil, and resulted in a very material increase in meter torque output.

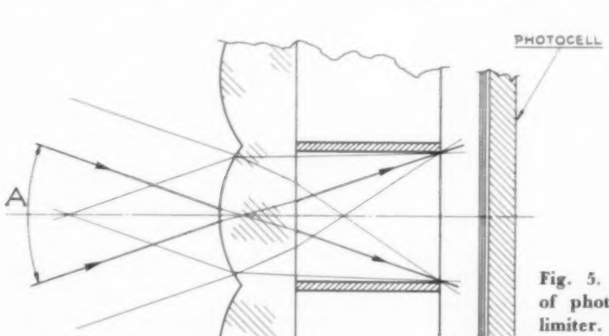


Fig. 5. Refraction type of photocell field angle limiter. "A" represents the angle within which direct rays are transmitted to the photocell.

The Iris

Since the sole reason for devising such a radically different iris was to obtain the absolute minimum of frictional resistance, it was necessary to keep the size (and consequent weight) of the iris as small as possible. A further incentive in this direction, as mentioned previously, was the limited space available for the iris. The minimum diameter of the iris gears in Fig. 1 is primarily dependent on the required iris opening diameter, and was derived algebraically. The necessary stock thickness of the blades was determined by a flatness tolerance, these two characteristics being strongly influenced by limitations imposed on the overall iris thickness by the camera optics. The selection of blade material (brass) was

based on available manufacturing methods which could produce such a flatness in the selected stock thickness.

It was also desirable for weight and space reasons to keep the meter gear diameter to a minimum. Here the main consideration was that the angular movement of the iris gears and the resulting length of their iris slots must be sufficient to avoid excessive errors in iris area. Ten degrees per lens stop was found to be about the minimum travel allowable for the intended iris gear diameter. The selected photocell loading and meter sensitivity had already resulted in a meter deflection of 15.6° per stop, and this combined with the iris gear diameter determined the necessary meter gear diameter. This diameter was found to be acceptable with respect to the space available as well as practical from the standpoint of the desired meter construction. If this had not been so, a re-evaluation of photocell loading and meter sensitivity would then have been necessary. Sufficient information was then available so that the torque requirements of the system could be calculated.

The described system is feasible only if the frictional load of the iris, meter gear and meter coil does not cause significant "dead space" in the position of the iris, though the amount of dead space which can be tolerated is not as small as would be expected at first glance. Since some slight vibration would be transmitted to the iris and meter bearings by the camera mechanism, error caused by any reasonable frictional resistance was expected to disappear promptly upon operation of the camera. This reasoning led to the tentative allowance of plus or minus one-third lens stop of frictional dead space against which the proposed design was evaluated.

Primary factors affecting friction in the system were meter coil and gear weight, iris weight, gear ratio, and bearing configuration. All of these factors were known with the exception of the bearing design. However, the meter bearing constants were soon determined by the comparatively great weight of the coil and gear, together with insistence on high shock resistance. In general, the shock resistance of a conical bearing increases as the spherical radius of the pivot is increased. At the same time, this increases the frictional radius of the bearing and greater frictional torque results. Extremely tough pivot and jewel materials can be used to reduce the pivot radius while still obtaining sufficient shock resistance, and hard steel pivots in sapphire jewels were finally selected for the meter bearings. Design of the iris gear bearings was not so critical, since each iris gear is only about one-third as heavy as the meter coil. It was found that this smaller weight allowed the use of commercially available steel jewels.

Next, the frictional torque of the system was computed back to the meter. By this time, the meter design was completed to the point where its delivered torque per degree was known, and therefore its delivered torque per lens stop. The frictional torque divided by the delivered torque per lens stop then represented the actual frictional dead space to be expected, and was found to be comfortably below the allowed one-third lens stop.

Camera Operation

The completed camera is shown in Fig. 4. As with most 8mm cameras, the depth of field of the lens is sufficient so that focusing is not required. No adjustment for camera speed is necessary, since only the normal speed of 16 frames/sec is provided. In addition, the automatic iris control makes it unnecessary to adjust the lens opening. Only one adjustment must be made (photocell mask) depending on which of the two films is being used. Simplification of the camera is almost complete with the operations necessary to make movies having been reduced to four:

(1) set mask for the film being used,

(2) insert film,

(3) wind camera, and

(4) press the button.

It should be pointed out that the flexibility of the camera has not been reduced by the addition of the automatic iris, since the lens iris can still be set manually to any desired opening for special effects, titling, or less commonly used films.

Additional Refinements

With respect to simplification, we realized that we had not yet gone all the way, since the customer was still required to adjust a photocell mask to whichever of two types of film he was using. In examining this situation it was realized that for all practical purposes outdoor photography always used an ASA 10 emulsion speed, and indoor photography always used ASA 16. A negligible exception to this was the possibility of using the ASA 10 film indoors with a filter, but the resulting low emulsion speed with this combination is not very useful.

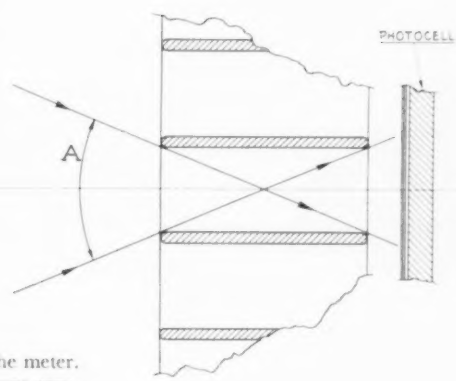


Fig. 6. Grid type of photocell field angle limiter.

With this mutually exclusive usage of emulsion speeds, if the photocell could be made less sensitive to daylight than to tungsten illumination, and in the proper ratio, the iris would then open up in daylight to compensate for the lower daylight emulsion speed. Harold McKinlay proposed to accomplish this with a blue-absorbing filter permanently placed over the photocell. When the camera is used outdoors, the filter absorbs much of the shorter (blue) wavelengths so that less light energy reaches the photocell, and the iris consequently opens wider. When used indoors practically all of the tungsten illumination reaches the photocell, since only a small portion of this illumination consists of the shorter wavelengths. The photocell generates a higher current, the meter deflects further, and the iris thus closes down for the faster indoor film. This filter reduces camera operations to the extreme of only "load, wind, and shoot."

A further improvement involved the characteristics of the field angle limiter used in conjunction with the photocell. The type of field limiter used in previous automatic cameras had been selected because of its efficiency in transmitting light to the photocell. This limiter (Fig. 5) theoretically transmits a high and virtually uniform percentage of light within its angular field of view, and none whatever outside this field. In practice, due to various factors such as reflections in the interior of the baffle, imperfect lens elements, and similar departures from the ideal, less perfect but still desirable characteristics are obtained. A further and more serious degradation can occur if the reticular lens is allowed to become dirty or scratched. For example, in a scene where direct sunlight strikes the reticular lens but where the subject is quite dark, the dirt and scratches are brightly illuminated and reradiate light to the photocell. While this reradiated light is minute, it can constitute an appreciable portion of the total light reaching the photocell from a low brightness scene, and an underexposure error results. It was found that a simple egg-crate type of grid (Fig. 6), while its

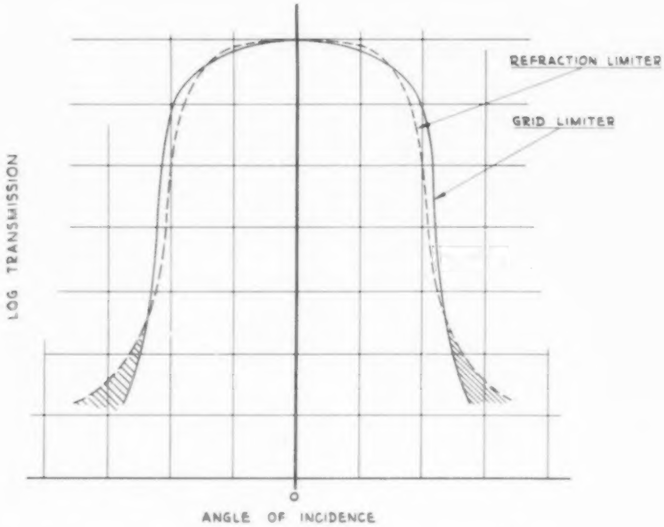


Fig. 7. Transmission characteristics of grid and refraction limiters.

Fig. 8. Bell & Howell Design 392 camera.

theoretical characteristics were not as good as the "ideal" performance of the reticular lens, actually performed the required function in a better manner. Figure 7 illustrates the difference in performance of these two types of limiters. The shaded areas of Fig. 7 are those in which the transmission characteristics have been improved. Such a grid is now being used in these cameras, with the filter described above being incorporated behind the grid to prevent direct physical access to the photocell. Figure 8 shows a later model of this camera in which these improvements have been incorporated.

Fig. 9. Bell & Howell Design 393 camera.

Another change was the result of an anticipated customer question, "If this is really a fully automatic camera why do you have this little knob to set the iris?" While the main function of the knob was to prevent a loss of camera flexibility, we certainly did not intend to force it onto a customer who did not mind the loss. As a result, some models of the camera are now being sold without this adjustment.

While telephoto and wide-angle attachments can be used with the cameras described previously, a turret is the more convenient means of changing lens focal length. Additional space and functional limitations imposed by the photocell and meter made the provision of a turret more difficult in this application. A more compact turret was required than would be obtained by the conventional method of mounting the attachment optics in separate barrels, so a new turret was devised in which all of the attachment optics are mounted in a common die casting. A decided reduction in turret size is obtained since the adjacent optical systems need be separated only by a single wall, rather than by two walls and an air space. A die-cast chromium-plated cover plate conceals the turret center post, and also carries the markings which identify the normal, telephoto and wide-angle lens positions. This camera is shown in Figure 9.

Characteristics

This direct-drive automatic iris control has some unusual characteristics. External accelerations, whether linear or rotational, have very little, if any, effect on the moving parts. Notwithstanding this virtual immunity to the effect of external accelerations, the response speed is a spectacular six lens stops per second due to the very low rotational inertia of the moving parts. In spite of this high response speed there is no noticeable overshooting. Because there is no need to be economical of power from the photocell, the system is always in operation. By the time the user has properly framed his picture and begun to expose film, the iris has long since reached its proper opening.

Shock resistance was an earlier consideration, and for a short time was a source of concern because of the apparent delicacy of the components used. This concern was voiced by so many people in our organization that some means of removing their concern was necessary. We made up a small package which we called a "shock test kit" and which contained a piece of wood and a handful of nails. Each time the question of delicacy was asked, one of us would proceed to drive a few of the nails into the wood, using the camera as a hammer. Such questions soon ceased, since the only effect of this treatment was to chip some paint off the bottom of the camera.

Another question which received little attention at first was how long the system could be expected to operate. The answer that its service life exceeded that of the camera was only temporarily satisfactory, and a life test (in addition to the previous acceptance test) was begun. The life test consisted of a lamp which was rapidly turned on and off with a timer, and which caused the iris to be driven continuously from one end of its range to the other. This test, which has now reached seven million cycles with no ill effects to the camera, has so far burned out five lamps, a timer and a counter.

A Method for the Evaluation of the Spectral Characteristics of Color Screens

By KARL WEISS

A method is described for measuring the spectral transmission of the individual elements of color screens. The procedure involves the use of masks to block selectively the unwanted colors in order to allow spectrophotometric measurements to be made on the chosen color.

Color screens form the basis of a number of well-known additive color processes such as Dufay color and Johnson color. In the development of such processes it is important to have available accurate data on the spectral characteristics of the color screen.

Manufacturers' data on commercially available color screens are highly idealized, and hence are not useful for assessing color separation. Furthermore, the color transmission of the microscopic elements of color screens prepared by a sequence of bleaching and dyeing operations differs significantly from the transmission of macroscopic filter areas prepared by an identical sequence of operations. The actual spectral data can therefore be obtained only from the screen itself. The means of accomplishing this is based on the preparation of a set of masks which, when accurately positioned, block out all the elements except those of one color.

Preparation of Masks

The color screen is placed in contact with Kodalith Pan plates in a specially constructed exposure frame. Exposure is made to tungsten light through subtractive filters, and the plates are processed in the normal way according to the manufacturer's direction.

A contribution submitted on April 9, 1958, by Karl Weiss, Dept. of Chemistry, New York University, University Heights, New York 53. This work was carried out in the laboratories of Color Research Corp. under the direction of Samuel B. Grimson.

The mask which allows passage of light through the red elements only must completely block the blue and green elements. This is achieved by exposure through a blue-green (cyan) filter which, on development, gives rise to silver deposits behind the blue and green elements only. Similarly, masks designed to allow passage of light through the blue elements only and the green elements only are prepared by exposure through yellow and magenta filters respectively. The exposure frame (Fig. 1) is designed to fit into the sample compartment of the Beckman Model DU spectrophotometer. Pilot pins allow the accurate positioning of a perforated color screen sample.

The following filter combinations are satisfactory for most color screens. Fine adjustments can usually be made by employing different color compensating filters.

Red Masks:	Wratten No. 44A and No. CC-50M
Green Masks:	Wratten No. 34
Blue Masks:	Wratten No. 16, No. CC-40C and No. CC-50C

Even and accurately reproducible exposures are obtained by the use of a small, low intensity diffuse light source at a distance of 8 ft. For silver deposits of uniformly high density the exposure ratios are approximately 3:1.5:1 for the red, green and the blue masks, respectively.

Although it is unlikely that, for a particular mask, the exposure through the two screen elements to be blocked is exactly the same, the inherently high contrast of the Kodalith plate produces such dense silver deposits that any difference is not measurable.

Spectral Measurements

To measure the spectral transmission of a particular screen element, the corresponding mask is placed in contact with the color screen in the exposure frame. By using the same piece of color screen from which the mask was originally prepared, spurious pinholes arising from localized imperfections are avoided. The mask is accurately positioned to block the unwanted elements with the aid of a high-power microscope. Adjustments are made until the registration between mask and screen is perfect in the four corners and the center of the frame. The combination is then locked in position, and the optical densities in the visual region are determined with the spectrophotometer. In order to use this instrument in its photometrically most useful range, it is desirable to compensate for the absorption of the mask. This may be done by placing an identical mask in the reference beam. Alternatively a neutral density filter may be used. Since such filters absorb quite selectively, it is necessary to determine their absorption separately, and to correct the spectra accordingly.

The spectral characteristics of the individual elements of a typical color screen are shown in Fig. 2. The screen used in this example contains 550 elements of each color per linear inch.

Acknowledgment: The exposure frame shown in Fig. 1 was designed and constructed by Frederick T. O'Grady.

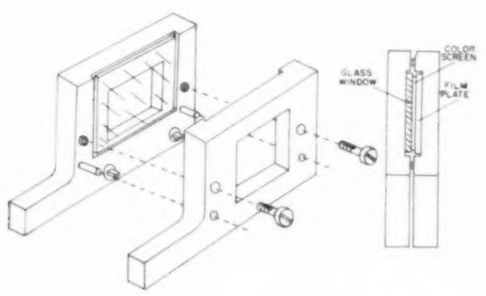


Fig. 1 Exposure frame.

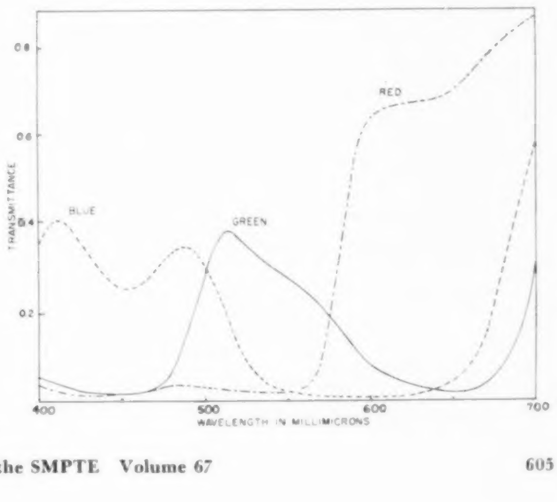


Fig. 2. Response of typical color screen.

Recommended Practice for

Reporting Photometric Performance of Incandescent Filament Lighting Units

Used in Theatre and Television Production

Prepared by the Joint I.E.S.-S.M.P.T.E. Committee on Equipment Performance Ratings

Foreword

The Recommended Practice presented herewith represents three years work by the participating committees. Of necessity it resulted in the formation of an inter-society committee, the Joint I.E.S.-S.M.P.T.E.* Committee on Equipment Performance Ratings.

The original charge to the Joint Committee was to establish a uniform method of reporting the photometric performance of lighting units used in theatre, television and motion picture production. As the work progressed the Joint Committee requested a more limited scope of study; accordingly the present report is limited to incandescent filament lighting units used in theatre and television production. It is hoped, nevertheless, that a basis has been established for further study on units requiring other than incandescent filament sources, and on units used in the motion picture industry where they differ from those reported herein.

For purposes of actual test procedure the Joint Committee has depended upon the various I.E.S. guides on photometry and photometric testing listed in Section 4. For the materials on incandescent filament sources presented in Appendix A,** the Joint Committee is heavily indebted to the Light Sources Committee of the I.E.S.

The Recommended Practice has been subjected to close review and criticism by many leading photometric testing engineers as well as lighting designers, engineers and operating personnel in the theatre and television production fields. No effort has been spared to make this Practice authentic and practical. Every effort has been put forward to encourage uniformity in reporting sound engineering data on the lighting units described herein.

As with other guides or recommended practices, it is of course true that this Practice is of value only to the extent it is accepted and used by the lighting profession and the lighting industry. The Joint Committee recommends the following procedures and expresses the hope that they will find immediate acceptance by the members of I.E.S., S.M.P.T.E., and the lighting industry.

Joint I.E.S.-S.M.P.T.E. Committee on Equipment Performance Ratings

Joel E. Rubin, *Chairman*

Subcommittee on Lighting Equipment Performance Ratings of the Committee on Theatre and Television Lighting of I.E.S.

Alfred W. Boylen — Walter O'Meara
Stanley McCandless — Kenneth Palius
Rollo Gillespie Williams

Subcommittee on Equipment Performance Ratings of the Television Studio Lighting Committee of S.M.P.T.E.

Frank E. Carlson — H. M. Gurin
George T. Howard — Robert M. Morris

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Herbert A. Kliegl

1. Objectives

(a) This recommended practice is designed to establish a uniform method of reporting the photometric performance of incandescent filament lighting units used in theatre and television production.

(b) This recommended practice specifies the particular data which shall be included, as a minimum requirement, for a photometric report of such units.

(c) An effort is made to standardize

*Illuminating Engineering Society–Society of Motion Picture and Television Engineers.
**Not published here. Data from third edition of *IES Lighting Handbook.*

Approved by the Council of the Illuminating Engineering Society, October 1957. A Transaction of the Society.

TABLE I — Schedule of Lamp Life Hours and Filament Forms for Reporting Data as per Section 3(b).

Type of Equipment	Wattage	Rated Life in Hours	Filament Form*
Fresnel-lens spotlights	up to and including 2000	200	C-13
	5000	150	C-13
	10,000	75	C-13
Ellipsoidal-reflector spotlights	up to and including 2000	200	C-13D
	3000-5000	100	C-13D
Plano-convex-lens spotlights	up to and including 2000	200	C-5
Follow spotlights	all	rated life of lamp used	—
Scoops, Floodlights and Striplights employing 750-1000 hour lamps	up to and including 60	1000	—
	75-300 (Medium Base)	750	—
	300-2000 (Mogul Base)	1000	—
Parabolic-reflector projectors	up to and including 750	200	C-13
	1000-2000	200	C-5
PAR and R lamps in housings	all	2000 (except for special lamps)	—
Scenic projector units	all	rated life of lamp used	—

*When available in test wattage.

the terminology employed in presentation of data.

2. General Information to be Reported

(a) The data sheet carrying test performance data shall note: the name of the manufacturer of the lighting unit; its catalog number or identification; trade name if any; and a description of the type of unit such as "ellipsoidal reflector spotlight," "striplight," etc.

(b) The test performance data sheet shall note the date of test and the laboratory where it was performed.

(c) The manufacturer shall describe on the data sheet the following significant physical properties of the lighting unit:

(1) Major dimensions,
(2) Light source,
(3) Material of reflecting surface (or surfaces),
(4) Optical elements (light source, reflector, lens),
(5) Optical adjustments (light source, reflector, lens).

NOTE: Information about a unit's weight, optical adjustment mechanism, and normally included wiring and accessories would be helpful.

3. Light Source Information to be Reported

(a) The following information concerning the test lamp shall be reported:

(1) Nominal wattage of lamp,
(2) Design voltage of lamp,
(3) Rated life of lamp in hours,
(4) Type of lamp filament,
(5) Initial lumen output of lamp (see (c) below),
(6) Bulb shape, size and base,
(7) Recommended burning position,
(8) Approximate initial color temperature in degrees Kelvin.

(b) While a manufacturer may report the performance of his equipment using any type of incandescent filament lamp he elects, he shall also include photometric data using one or more of the lamps described by the proper category in Table I.

(c) The photometric data for the lamp used in testing shall be corrected to conform with the estimated initial lumen output for the lamp as published in the *IES Lighting Handbook*, some of which data is reproduced in Appendix A* for convenience. In the event that a lamp is not specified therein, then the data shall be corrected to conform to the lamp manufacturer's published lumens and so stated.

4. Test Procedure for Obtaining Data

4.1—*General*— The test procedure in general shall conform to the pertinent sections of any or all of the following:

(a) I.E.S. Practical Guide to Photometry,**
(b) I.E.S. General Guide to Photometry,
(c) I.E.S. Guide for the Photometric Testing of Floodlights of 10 to 160 Degrees Total Beam Spread,
(d) I.E.S. Guide for Photometric Testing of Searchlights.

*Not published here — Data from third edition of the *IES Lighting Handbook*.
**In preparation.

4.2—*Minimum Requirements in Obtaining Photometric Data*

4.2.1—*Distribution Symmetrical Around the Optical Axis* — Data for each candlepower distribution curve shall be the average of readings in four planes common to the optical axis: the vertical, horizontal, and two 45-degree planes.

4.2.2—*Asymmetrical Distribution* — For any unit in which the distribution is intended to be asymmetrical about the optical axis, data for more than one curve shall be presented so as to show the asymmetry of the candlepower distribution.

4.2.3—*Number of Readings* — There shall be approximately twenty (20) readings per plane, distributed so as to describe the beam accurately.

4.3—*Test Conditions for Specific Lighting Units*

4.3.1—*Ellipsoidal-Reflector Spotlights* — The lens system is to be adjusted to its sharpest focus. The lamp is to be adjusted to produce a beam of greatest uniformity. The aperture shall be at its maximum opening.

4.3.2—*Fresnel-Lens Spotlights and Plano-Convex Lens Spotlights* — Separate groups of data shall be reported for at least two focus positions: (1) full flood, and (2) spot. These positions shall be designated by the manufacturer who may also designate additional focus positions.

4.3.3—*Variable Focal Length Multi-lens System Spotlights* — Separate groups of data shall be reported for at least two focus positions: (1) full flood, and (2) spot. These positions shall be designated by the manufacturer who may also designate additional focus positions.

4.3.4—*Variable Focus Parabolic—Reflector Floodlights* — Data shall be reported for the lamp filament at the focal point of the reflector. Additional data shall be reported for any other point (or points) that the manufacturer shall designate.

4.3.5—*Striplights* — Distribution curves for a single lamp and reflector combination and/or lens in the striplight shall be obtained for planes

TABLE II — Throw Distance for Illumination Curves as per Section 5.3.1.

Type of Equipment	Wattage	Distance
Fresnel-lens spotlight	75 - 150	5′
	250 - 750	15′
	1000 - 2000	20′
	5000: at spot focus	60′
	5000: at flood focus	30′
	10,000: at spot focus	60′
	10,000: at flood focus	30′
Ellipsoidal-reflector spotlight	250 - 750	20′
	1000 - 2000	30′
	3000 - 5000	50′
Plano-convex lens spotlight	250 - 400	10′
	500 - 1000	20′
	1500 - 2000	20′
Follow spotlight	all sizes	100′
Floodlights and scoops	300 - 500	10′
	750 - 2000	15′
Parabolic-reflector projectors	250 - 750	25′
	1000 - 2000	50′
PAR and R reflector lamps in housings	all sizes	15′
Striplights	all sizes	see computation required in 4.3.5
Scenic projection units	all sizes	20′

through the maximum candlepower axes, parallel and perpendicular to the long dimensions of the striplight. In addition footcandle computations showing the additive effect obtained from a number of lamp units placed at the lamp spacings for a single circuit used by the manufacturer, shall be reported for throw distances of 5 feet and 15 feet on a line parallel with the striplight.

4.4—*Spectral Determination*— It is desirable that the spectral distribution curve be provided for each lighting unit tested, using the light sources indicated in the schedule of Table I.

5. Photometric Information to be Presented

5.1—*General*— Candlepower and illumination curves, field angle,* beam angle,** the total lumens in the field, and the total lumens in the beam shall be presented.

5.2—*Candlepower Distribution Curve*— (a) A candlepower distribution curve (or curves if required) shall be presented for each lighting unit. Such curves are to be plotted on rectilinear coordinates and shall be an accurate candlepower profile of the unit's light distribution taken on a spherical surface. The curves are to be plotted using candlepower as the ordinate versus degrees as the abscissa.

(b) The candlepower distribution curve of each lighting unit shall be referred to the mechanical axis of the unit and shall extend beyond the point where the candlepower is 10 per cent of maximum candlepower.

5.3—*Illumination Curve*— An illumination curve (or curves if required) shall be presented for each lighting unit. Such curves are to be plotted on rectilinear coordinates, and shall be calculated from the candlepower distribution curve for the single instance of a plane perpendicular to the mechanical axis at a given throw distance from the lighting unit. The curves are to be plotted using footcandles as the ordinate versus feet as the abscissa.

5.3.1—*Throw Distance*— The illumination curve or curves for the lighting unit is to be plotted at the throw distance indicated in Table II.

5.4—*Conversion Factors*— (a) Multiplying factors for conversion of the illumination curve data for use at other throw distances shall be provided as shown in Appendix B.

(b) The following statement shall appear on the test Performance Data Sheet: "To convert the candlepower distribution curve (or curves) to illumination curve (or curves) on a spherical surface with the lighting unit as its center, divide the candlepower values by the square of the radius (throw distance) in feet. (Invalid at less than ____ feet.)" The distance reference shall be twenty times the lens diameter of the lighting unit. In the case of lensless lighting units the diameter of the reflector may be considered as the effective diameter.

5.5—*Field and Field Angle*— Those points of the curve where the candlepower is 10 per cent of maximum candlepower shall define the field of the lighting unit. The included angle shall be defined as the field angle.

5.6—*Beam and Beam Angle*— Those points of the curve where the candlepower is 50 per cent of maximum candlepower shall define the beam of the lighting unit. The included angle shall be defined as beam angle.

*See Section 5.5.
**See Section 5.6.

Appendix A—Technical Information on Lamps Used for Testing and Reporting Data will appear in the reprint of this report.

Appendix B — Conversion Factors as per Section 5.4 (a).

Multiplying factors for conversion of the illumination curve data for use at other throw distances are provided on the next page. It should be noted that these values may be considered accurate only when there is a minimum ratio of 20:1 for the object-to-lens distance as compared with the lens diameter. In the case of lens-less lighting units the diameter of the reflector may be considered as the effective diameter.

Curve Throw Distance	Actual Throw Distance	Multiply Dimensions by	Multiply Illumination by
5 feet	5.0 feet	1.0	1.0
	7.5	1.5	0.44
	10.0	2.0	0.25
	12.5	2.5	0.16
	15.0	3.0	0.11
10 feet	7.5 feet	0.75	1.8
	10.0	1.0	1.0
	15.0	1.5	0.44
	20.0	2.0	0.25
	25.0	2.5	0.16
	30.0	3.0	0.11
15 feet	10.0 feet	0.66	2.25
	15.0	1.0	1.0
	20.0	1.3	0.56
	25.0	1.7	0.36
	30.0	2.0	0.25
	40.0	2.7	0.14
	50.0	3.3	0.09
20 feet	10 feet	0.5	4.0
	15	0.75	1.8
	20	1.0	1.0
	25	1.25	0.64
	30	1.5	0.44
	35	1.75	0.32
	40	2.0	0.25
	50	2.5	0.16
25 feet	10 feet	0.4	6.3
	15	0.6	2.8
	20	0.8	1.5
	25	1.0	1.0
	30	1.2	0.69
	35	1.4	0.51
	40	1.6	0.39
	50	2.0	0.25

Curve Throw Distance	Actual Throw Distance	Multiply Dimensions by	Multiply Illumination by
30 feet	10 feet	0.33	9.0
	15	0.5	4.0
	20	0.67	2.25
	25	0.83	1.44
	30	1.0	1.0
	35	1.16	0.73
	40	1.3	0.56
	45	1.5	0.44
	50	1.7	0.36
	60	2.0	0.25
50 feet	25 feet	0.5	4.0
	40	0.8	1.5
	50	1.0	1.0
	60	1.2	0.69
	75	1.5	0.44
	100	2.0	0.25
60 feet	20 feet	0.33	9.0
	30	0.5	4.0
	40	0.67	2.25
	50	0.83	1.44
	60	1.0	1.0
	70	1.16	0.73
	80	1.3	0.56
	90	1.5	0.44
	100	1.7	0.36
100 feet	50 feet	0.5	4.0
	75	0.75	1.8
	100	1.0	1.0
	125	1.25	0.64
	150	1.5	0.44
	175	1.75	0.32
	200	2.0	0.25

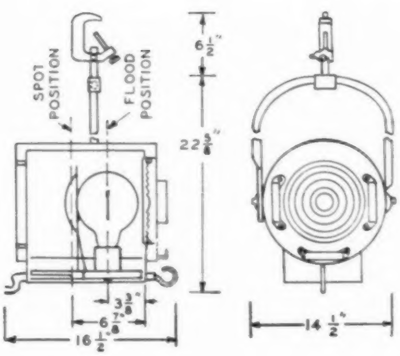
Appendix C—A Typical Form for a Data Sheet

Lighting Equipment Performance Data Sheet

Manufacturer's Company Name XYZ Laboratories
Catalog No. or Identification 2735 Trade Name Fres-Light
Type of Unit Fresnel-lens Spotlight

Physical Properties

Light Source Incandescent Filament Lamp
Optical Elements
Lens 8 x 5 Fresnel, heat-resisting, painted risers
Reflector specular Alzak, spherical spun reflector, 5" diameter
Other



Optical Adjustments Relation between lamp and reflector fixed. Lamp carriage moves with relation to lens for spot to flood position
Adjustment Mechanisms screw feed drive for crank and pole operation
Weight of Unit 25 pounds
Wiring and Accessories 30" asbestos leads, 2-wire or 2-wire plus ground

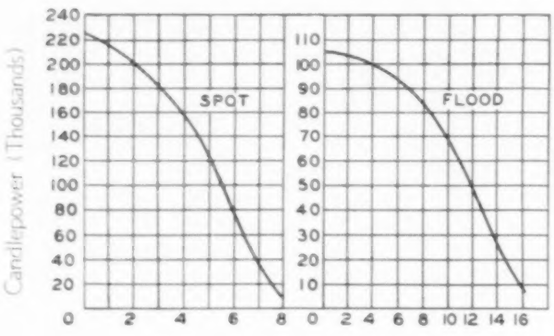
Test Lamp Data

Lamp Designation	2M/G48/17	Initial Lumens	53,000
Nominal Watts	2000	Bulb Shape and Size	G48
Design Volts	120	Base	mogul bipost
Rated Life	200 hours	Recommended	
Filament Form	C13	Burning Position	base down

Approximate Initial Color Temperature 3150°K

Test Date	-----	Test Laboratory	XYZ Laboratories
Report No.	683	Approved by	XYZ

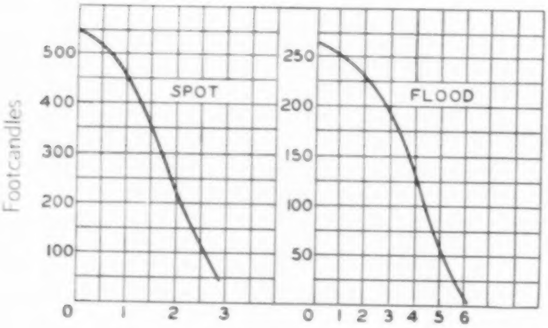
Photometric Test Data
Candlepower Distribution



Illumination on a Plane at Right Angles to the Mechanical Axis of the Lighting Unit Calculated for 20 feet throw distance

	Flood	Spot
Field Angle	31°	15°
Field Lumens	13,500	6,200
Beam Angle	24°	11°
Beam Lumens	11,700	5,050

Note: Candlepower curve(s) determined from data taken at 30 feet.



Illumination on a Spherical Surface

Multiplying Factors

Actual Throw Distance	Multiply Dimensions By	Multiply Illumination By
10	0.5	4.0
15	.75	1.8
20	1.0	1.0
25	1.25	.64
30	1.5	.44
35	1.75	.32
40	2.0	.25
50	2.5	.16

To convert the candlepower distribution curve (or curves) to illumination curve (or curves) on a spherical surface with the lighting unit as its center, divide the candlepower values by the square of the radius (throw distance) in feet. (Invalid at less than 14 feet.)

news and reports

84th Convention Detroit October 20-24

As Convention preparations move on to the final stage a promise that the 1958 Fall Convention will be a memorable one is based on groups of papers on live, up-to-the-minute subjects, arranged by Program Chairman Heppberger, his associate Harold Kinzle and the Topic Chairmen and Regional Chairmen. The Equipment Exhibit is described in detail below. Also, there are firm plans for unusual and instructive entertainment activities and excellent cooperation among all concerned with arrangements. Topic Chairmen and their duties were listed in the May *Journal;* Local Arrangements Chairmen, in the July *Journal.*

A program of tours to points of interest in and near Detroit has been arranged for the Ladies Events, but men, too, may especially want to go on the tour of the General Motors Technical Research Center where demonstrations will be given in the GM styling studios. Those interested in Victorian bibelots and other Americana will appreciate the trip to Greenfield Village to view the famous Henry Ford collection; and for those whose interests include contemporary art and architecture a tour of the renowned school of art and architecture in Cranbrook has been planned. Visits to nearby points of interest in Canada can be arranged.

The Awards Session, always an event of special significance, will be held Tuesday evening, October 21. Forecasts of the awards appeared in the August *Journal* and are completed in this issue.

It is customary to remind possible procrastinators that, in order to avoid disappointments and to insure a rewarding and delightful time at the Convention, details of registration and hotel reservations should be attended to at once. The postal announcement, mailed early this month to members, has a detachable addressed card to be mailed to the Reservation Dept. of the Sheraton-Cadillac Hotel, Detroit 31. There is also a card to be enclosed with the advance registration fees which should be received at headquarters no later than October 10. A discount of $2.00 is made when the fee for the banquet and luncheon is sent with the registration fee, making a total of $22.50 for registration, banquet and luncheon. Registration fee for members is $5.00. The banquet ticket, without discount, is $15.00 and the luncheon is $4.50.

Equipment Exhibit

The roster of exhibitors continues to increase and it is evident that visitors to the convention will have the opportunity of seeing as fine a display of professional motion-picture and television equipment as has ever been gathered together in the Detroit area. Several companies will have new developments that will be shown for the first time anywhere. Free passes for admission to the exhibit will be available at the Registration Desk.

Companies who are preparing displays include:

Animation Equipment Corp.
Bell & Howell Co.
Camera Equipment Co.
Canadian Applied Research Ltd.
Andre Debrie Mfg. Corp.
Electronic Systems of Illinois Inc.
Florman & Babb Inc.
Harwald, Inc.
Karl Heitz Inc.
HiSpeed Equipment Inc.
Hollywood Film Co.
Kling Photo Corp.
Lipsner-Smith Corp.
Macbeth Instrument Corp.
Motion Picture Printing Equipment Co.
Neumade Products Corp.
Precision Laboratories
Reevesound Co.
Ro-Nan Inc.
S.O.S. Cinema Supply Corp.
Unicorn Engineering Co.
Westrex Corp.
Wollensak Optical Co.

Information about any space remaining can be obtained from the Exhibit Chairman, Ray Balousek, c/o Producers Color Service, 24 Custer, Detroit 2, Mich.

Advance Program

Minor changes, necessitating rescheduling of certain events on the program have, at times, occurred after publication of the Advance Program. Changes, involving addition of certain papers, changes in those already scheduled or in the time allotted to certain events, committee meetings, etc., may be made before or during the Convention. The program published here is complete to the date of publication and, unless some unforeseen and unavoidable event occurs, the Convention will proceed according to this schedule.

Detailed information is available from SMPTE headquarters in New York (LOngacre 5-0172). During the week preceding the Convention it is advisable to make inquiries by telephone, especially those relating to scheduling of individual papers, committee meetings and other matters of immediate importance. Information relating to the scheduling of papers may also be obtained directly from the Program Chairman, C. E. Heppberger, by telephoning him at Chicago, Financial 6-3300.

SUNDAY—OCTOBER 19

2:00 Registration opens in the Sheraton-Cadillac, Detroit

MONDAY—OCTOBER 20

8:30 Registration

9:00 LABORATORY PRACTICE

Photographic Processing Equipment
JOHN R. TURNER, *Color Technology Div., Eastman Kodak Co., Rochester, N.Y.*
Conventional methods cf photographic processing and the functional elements of processing machines such as drives, recirculation systems and agitation devices are reviewed in detail, particularly as related to motion-picture film. Note is taken of techniques, evolved in related fields, that represent a wide departure from these practices both in simplicity and in speed. Also discussed are some photographic processing methods which as yet have had only limited commercial application but which offer comparable possibilities of increased speed and simplicity.

The Bell & Howell Additive Color Printer
HANS-CHRISTOPH WOHLRAB, *Bell & Howell Co., Chicago*
Additive color printing is easy because the light can be controlled by mechanical devices and the program for printing may be predetermined and stored in a perforated tape. The perforator provides signals for starting and stopping the printer, light values for red, green and blue, and provides for fades in three different speeds. The reader feeds this information into the printer. The printer operation is described.

An Improved 16mm Tear Detector for Film Processing Machines
FRANK E. WHITE and JOHN FEDERICO, *Processing Lab., Eastman Kodak Co., Chicago*
The detector is composed of three parts: the run-through roller, the tear detector, and the film brake. When the end of the film passes through the run-through roller, a pressure roller actuates a microswitch energizing the film brake. When a torn perforation or misaligned splice passes under the tear detector, the fork actuates a microswitch, thus energizing the film brake. The film brake consists of roller and pressure roller, behind which is a pawl and ratchet. The pawl is actuated by a solenoid, which in turn is energized by either of the two microswitches as mentioned above.

An Automatic Shutter Control for D & J Printer
HANS-CHRISTOPH WOHLRAB, *Bell & Howell Co., Chicago*
At the present increased printing speeds, hand setting of light changes is difficult and unreliable. The automatic shutter control kit which is described can easily be mounted on any D&J printer, and utilizes tape code and perforator presently available for the additive color printer. The control operates on 22 light steps incorporating fade release and automatic printer start and stop, including a dynamic braking device to avoid coasting of the printer. Good accessibility of all components facilitates servicing.

The Effect of Developing Time Upon Distortion in Variable-Area Recording
GEORGE LEWIN, *Army Pictorial Center, Long Island City, N.Y.*
Variable-area sound recording on film was originally thought to be immune from processing variations. While the effect of exposure and density upon cross-modulation distortion has long since been recognized and is well documented over the years, the significance of developing time is generally overlooked. It is shown that the common practice of adjusting developing time to compensate for exposure errors is not satisfactory. Large errors can never be fully compensated, and small errors are shown to require overcompensation if the optimum print density is to remain unchanged. The need for further study of the effect of changes in the developer itself upon cross-modulation is indicated.

Laboratory Problems and Procedures in Processing Color Negative in the Cinemiracle Process and Preparation of Theater Prints Therefrom
PAUL A. KAUFMAN, *Tri-Art Color Corp., New York; and* COLEMAN T. CONROY, JR., *National Theatres, Inc., Los Angeles*
Louis de Rochemont's first Cinemiracle Adventure film *Windjammer*, produced for National Theatres, Inc., was photographed on 35mm Eastman Color Negative, Type 5248. Laboratory procedures in processing the negative, timing, color balancing, printing and vignetting Cinemiracle release prints are discussed.

A Technique for Reducing Contrast for Special Purposes in Printing From Negatives of Normal or Excessive Contrast
PAUL A. KAUFMAN, FERDINAND INDIA and ROBERT M. SMITH, *Du-Art Film Laboratories, Inc., New York*
Owing to special requirements of the TV industry problems of severe contrast reduction have been imposed upon film processing laboratories printing from negatives which were photographed and processed for theater presentation. A technique has been developed whereby contrast reduction is effected with release positive stock under normal developing conditions. Other applications of this technique are also discussed.

12:15 Get-Together Luncheon

MONDAY AFTERNOON

2:30 SYMPOSIUM on 16mm Color Intermediate Negative/Positive Release Printing

A Symposium on the 16mm Internegative/-Positive Process
ROBERT A. COLBURN, Chairman, *Geo. W. Colburn Laboratory, Inc., Chicago*
Three 16mm motion-picture laboratories in the Midwest using the 16mm internegative/positive system of producing release prints describe the various methods used in their respective laboratories to obtain satisfactory prints. Each laboratory also describes special printing equipment that was designed and built by it for its exclusive use to meet the requirements of this system.

Preparation of Originals for 16mm Internegative/Positive Printing
ROBERT A. COLBURN, *Geo. W. Colburn Laboratory, Inc., Chicago*
The Geo. W. Colburn Laboratory sets up originals in A & B rolls to incorporate fades, lap dissolves and invisible splices; timing is both for color balance and exposure balance; originals are cued for automatic printer operation; and originals are treated to minimize Newton ring formation.

16mm Color Intermediate Negative-Positive Printing Procedures and Controls
JOHN R. STILLINGS, Lakeside Laboratory, Gary, Ind.
Printing procedures and control techniques using an additive printer in the production of 16mm color positive prints from 16mm reversal color film are described. Matrix algebra is used in determining a basic exposure for each emulsion type and number used. These matrices can be used for initial printer calibration as well as for routine printer control.

16mm Internegative and Positive Processing Controls
WILLIAM D. HEDDEN, *The Calvin Company, Kansas City, Mo.*
Processing control of 16mm color internegative and color positive is necessary to produce a high-quality product. This paper deals with methods of photographic and chemical processing production controls and their coordination with motion-picture printing controls.

Two New 16mm Printers Designed Especially for the Internegative and Color Positive Process
GEO. W. COLBURN, *Geo. W. Colburn Laboratory, Inc., Chicago*
The internegative printer is a contact step printer for daylight operation. A mechanical dissolve shutter will operate at two speeds. Light changes are accomplished by use of glass neutral density filters. Color filters are introduced automatically to make individual scene color-balance changes. The color positive printer operates at 300 ft/min and handles both color internegative and negative sound rolls in one pass.

Equipment for Printing 16mm Color Internegative and Color Positive Film
R. PAUL IRELAND, *EDL Company, Gary, Ind.*
Equipment for printing 16mm color internegative film differs from other 16mm printing equipment in only one essential way: considerably more exposure must be provided for color negative than for other films. There are several other differences which are desirable although not necessary.

The Colormatic Printer
LLOYD THOMPSON and KENNETH B. CURTIS, *The Calvin Co., Kansas City, Mo.*
The making of 16mm color prints from color original reversal by the internegative system is more difficult and exacting than making reversal prints. Black-and-white equipment demands extensive modification or new color equipment must be built. This paper outlines some of the problems and the details of a new high-speed production printer for making positive prints from the internegative.

MONDAY EVENING

7:30 DOCUMENTARY AND EDUCATIONAL FILM PRODUCTION

Milking the Oddball Camera
WILLIAM R. WITHERELL, JR., *Video Films, Detroit*
Without demeaning the importance of standard motion-picture equipment, it can be claimed that such gear, by virtue of its inflexibility, can be a limiting factor in approaching a production. The value of substandard, "oddball" equipment is stressed, with film examples. There is good reason to put emphasis on the creative freedom

Awards at the Convention

Presentation of Awards will take place Tuesday evening, October 21. The Awards ceremony represents one of the gravest responsibilities of the Society, that of designating the men whose achievements are of present importance and hold promise for the future. Following are the names of recipients, the Awards to be bestowed, and the names of the Chairmen of the Award Committees: to George Lewin, the Samuel L. Warner Memorial Award, Gordon E. Sawyer, Chairman; to Albert Rose, the David Sarnoff Award, William B. Lodge, Chairman; to Merle L. Dundon, the Herbert T. Kalmus Award, Herman H. Duerr, Chairman; to George Lewin, the Journal Award, S. P. Solow, Chairman. This award is for the paper on "The Infrared Transparency of Magnetic Tracks." Honorable Mention for papers published in the *Journal* will be awarded to Willy Borberg for "Effect of Gate and Shutter Characteristics on Screen Image Quality," Armin J. Hill for "Analysis of Background Process Screens," Donald Kirk, Jr., for "Economic Considerations in Closed-Circuit Television System Design" and R. G. Neuhauser for "Black Level — The Lost Ingredient in Television-Picture Fidelity."

The rank of Honorary Member will be bestowed upon Herbert T. Kalmus. Deane R. White is Chairman of the Committee on Honorary Membership.

Tentative Schedule of Committee Meetings

Monday, October 20
2:00 P.M. Film Dimensions
5:30 P.M. Association of Cinema Laboratories (including dinner)

Tuesday, October 21
10:00 A.M. Screen Brightness
10:00 A.M. Papers
11:15 A.M. Board of Editors
12:30 P.M. Editorial Luncheon
2:00 P.M. Film Projection Practice
2:00 P.M. Publications Advisory
3:00 P.M. Section and Student Chapter Officers

Wednesday, October 22
10:00 A.M. Public Relations Advisory
2:00 P.M. Education

Thursday, October 23
10:00 A.M. Sound
2:00 P.M. 16 & 8mm

Friday, October 24
10:00 A.M. High-Speed Photography
2:00 P.M. Television

Final schedule will be listed in the Convention Program and meeting notices will be mailed to Committee members.

inherent in the use of some nonprofessional cameras and recorders. Such thinking is recommended as an adjunct to, and not a substitute for, the generally accepted practices of our industry.

Documentary Film Productions of Conventions, Assemblies and/or Special Events
HENRY USHIJIMA, *John Colburn Assoc., Inc., Wilmette, Ill.*

Film Production in Central Africa
GEOFFREY T. C. MANGIN, *Central African Film Unit, Salisbury, S. Rhodesia, W. Africa*
Film activities in Central Africa include production of informational, advertising and educational films for theaters, for specialized audiences and especially for screening by mobile cinemas to the primitive indigenous African population. Technical facilities are limited but there are seven months of continuous sunshine. The hazards of dust, extreme changes of heat and humidity, and poor communications are special problems in making films of, and for, the African, and filming wild animals in the natural habitat.

Catching Bank Robbers With Cameras
ALFRED JENKINS, *Photoguard Corp., New York*
On April 12, 1957, three robbers held up a bank in Cleveland, and made a getaway, but their every action during the robbery has been photographed by a Photoguard Camera. The development of this camera and the problems of manufacturing equipment that is 100% reliable — even though it may not be used for years at a time — are described. Motion pictures of the robbery are shown and how they helped solve this crime will be discussed briefly.

The Unusual Films Motion-Picture Production and Training Unit at Bob Jones University
MRS. GILBERT STENHOLM, *Unusual Films, Bob Jones University, Greenville, S.C.*
The Unit produces and distributes in 16mm feature-length dramatic motion pictures on religious and educational themes, and travelogues, documentaries, and promotional short subjects. Comprehensive courses leading to the bachelor's and master's degrees in Cinema are offered. The physical studio and equipment facilities are on a scale unique among institutions of higher education. Unusual Films provides the "laboratory" for practical experience in all phases of motion pictures for students in the Division of Cinema of the Bob Jones University School of Fine Arts.

TUESDAY—OCTOBER 21

9:00 A NEW LOOK AT FILM TECHNIQUES FOR EDUCATION

New Perspectives for the Use of Film in Teaching
SOL ROSHAL, *Los Angeles*

Operations Research on Instructional Films
LORAN C. TWYFORD, *Michigan State University, Audio Visual Center, East Lansing, Mich.*
The needs for instructional films and how these needs are being met can be thought of as one operation. The factors in this operation include sound, picture, motion, color, cost, ease of preparation, use and maintenance, as well as other less important considerations. Instructional film research provides the guidance for evaluating the relative importance of these factors and points to films and equipment design considerations.

An Experimental Evaluation of Sound Filmstrips vs. Classroom Lectures
S. DWORKIN and A. N. HOLDEN, *Bell Telephone Laboratories, Murray Hill, N.J.*
Four, 45-min sound filmstrips on atomic bonding, produced by the authors, were tested with 120 graduate engineering students. Half were taught by the regular lecture and half by the filmstrips. An examination and a questionnaire indicated that there was no significant difference in learning between the two groups. Most of the students were willing to accept the sound filmstrips as a teacher substitute.

Films Help Break Teacher Education Bottleneck
ELLSWORTH C. DENT, *Coronet Instructional Films, Chicago*
Traditionally, teachers teach as they were taught. Hundreds of thousands of teachers in our schools today have been given little or no experience with educational films while receiving their training. Despite the more than sixty years since the development of motion pictures, less than 20% of America's 1,100,000 teachers are using films effectively in their classrooms. A broad program for teacher training to accelerate the teaching of future scientists and engineers is proposed.

Responsibilities of Classroom Film Producers
ALAN KELLOCK, *McGraw-Hill Text-Films, McGraw-Hill Book Co., New York*
In today's competitive world, with nations going all-out to strengthen their educational systems, the responsibilities of the classroom film producer take on a new and vital importance. He must choose subjects carefully to fit the curriculum, use competent subject matter advisers, and create scripts that will provide genuine learning experiences. He must be sure of technical production quality, and if desirable and practical, he should pretest his product before final release.

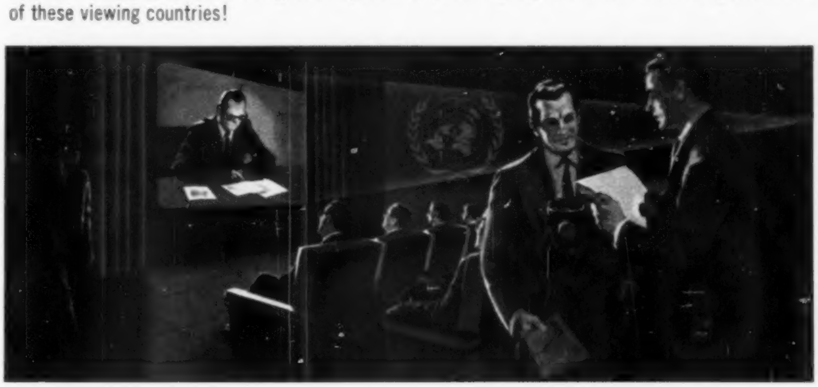
Brigham Young University's New Film Studio
ROBERT W. STUM and R. IRWIN GOODMAN, *Brigham Young University, Provo, Utah*
After five years of research and planning, the new motion-picture studio for the Department of Motion Picture Production of the Brigham Young University is nearing completion. Designed to carry an idea through from script to screen, the

Understanding among men...
Peace among Nations...

The ability of Datasync to speak simultaneously in ten different tongues, to sweep aside the misunderstanding and suspicion of strange words, to bridge the language barrier between nations of the world and further the cause of peace, this multi-tongued ability of Datasync deserves to be heard!

Multi-language TV broadcasting is already a reality on the "EuroVision" TV Network throughout Europe. Why not go a step further and bridge the oceans with Datasync?

For example, a "talking-picture" of a United States Delegate making a Speech, can be recorded along with nine other languages being spoken simultaneously by offical translators for listening Foreign Delegates. This ten-tongued Datasync "talking-picture" Photo-Tape can then be flown overseas within the hour, for use on local-language Television News Programs in Stockholm, Paris, Vienna, Rome, Cologne, Caracas, Bombay, Tokyo, etc. Thus the language barrier between Nations is bridged, with the Delegate's "speech for peace" going out in the native tongue of each of these viewing countries!



DATASYNC

A Multi-Channel transistorized Magnetic-Tape Recorder which also takes motion pictures on the same Photo-Tape.
DATASYNC Electronic-Optical Recording Systems are priced at $12,000.00 and up.

DATASYNC, PHOTO-TAPE AND LISTEN-IN ARE TRADE-MARKS OF BERNDT-BACH, INC.

Send for free illustrated Datasync "Catalog of Ideas" on your official or business letterhead. This Catalog is available to others at our Cost of Three Dollars Each.

DATASYNC
A DIVISION OF
BERNDT-BACH, INC.
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ELECTRONIC-OPTICAL INSTRUMENTS SINCE 1931

In the United States or overseas, public theatres or government review-rooms equipped with individual "Listen-In" wireless loud-speakers, allow the group-viewer to hear the language of his choice while watching the talking-picture on the screen, simply by turning a switch on his own "Listen-In". Private headphones can be used with the wireless loud-speaker unit when more convenient.

These multi-language films also find wide cultural and practical use at International World Fairs, Expositions, Political Meetings, International Business Conferences or Conventions, and for International Educational purposes. Thus Datasync bridges the language barrier and encourages understanding among men and peace among nations.

new facilities include an 80 by 100-ft soundstage; a two-story scenedock; integrated sound, projection and viewing setup; echo chamber; art and animation room; animation camera room; make-up and dressing rooms; camera and sound equipment repair shop; two editing rooms; and offices for writers and production personnel.

U. S. Film Production Training Overseas
DON WILLIAMS, *Syracuse University, Syracuse, N. Y.*

TUESDAY AFTERNOON

2:00 A NEW LOOK AT FILM TECHNIQUES FOR BUSINESS

Analysis of Growing Business Film Usage
JOHN FLORY and THOMAS W. HOPE, *Eastman Kodak Co., Rochester, N.Y.*
The chief areas in which business and industry are making use of motion pictures are: selling, advertising, public relations, employee training, and research and development. These applications account for two-thirds of the quarter-billion-dollar annual expenditures in the nontheatrical film field.

Motion Pictures — A Training Tool Used by Supervisors
E. H. PLANT, L. W. JENKINS and J. B. DeWITT, *Eastman Kodak Co., Rochester, N.Y.*
Supervisors at the executive offices of the Eastman Kodak Company are using low-cost "home-made" motion pictures to train their employees who, in turn, are encouraged to take pictures of operations, using the camera as a "thinking tool," just as they normally use a pencil. Conference rooms are designed for complete remote control operation by the supervisor doing the training: special lighting for different projection conditions, all 16mm film and slide projectors, plus provision for rear projection or even camera operation are at his finger tips. The techniques developed here are being widely adopted by other business and educational organizations.

New Trends in Low-Cost In-Plant Film Production
F. A. DENZ, *Remington Rand, Division of Sperry Rand Corp., Tonawanda, N.Y.*
The advent of high-quality, light-weight 16mm cameras, and magnetic-optical projectors, coupled with the new, faster film emulsions, provides increased opportunities for business and industry to use low-cost, internally produced training films. Technical problems encountered in this expanding audio-visual frontier are analyzed, along with equipment requirements and cost limitations.

Techniques for Visual Aids Production
NORMAN E. SALMONS, *Audio-Visual Service, Eastman Kodak Co., Rochester, N.Y.*
There are techniques and methods of producing relatively low-cost visual aids for business and industry. Although emphasis is on a system of "short term" production techniques, standards of appearance and effectiveness are kept high. Preparation of artwork and all phases of still photography in the visual aids field are discussed. This is a completely "visualized" presentation, showing examples of visual techniques in both black-and-white and color.

Facilities, Equipment and a System for Visual Aids Production
NORMAN E. SALMONS, *Audio-Visual Service, Eastman Kodak Co., Rochester, N.Y.*
The facilities, equipment and staff required for producing visual aids in an in-service photographic department for industry are described as those of the department in which the visual presentations in the previous paper were produced. Also, a simplified system of planning visual-aid sequences uses the individual who will present the talk as the expert on subject matter. A portion of the system, using storyboard techniques, is a very efficient production procedure.

Loop Films With Particular Reference to Their Adaptability in Verbal Skill Training
ROBERT K. DAKER, *Seminar Films, Inc., New York*
Loop films, long used in one form or another, were best known either as a means of concentrated study of a pictured situation or as a method for teaching mechanical skills. After 1953, when Capt. W. C. Eddy perfected a simple, easy-to-interchange cartridge-type loop absorber, the loop-film technique was adapted to verbal skill teaching. A first series of lessons, produced for teaching another language, were developed cooperatively by Seminar Films and a group at Harvard led by Dr. I. Richards and Christine Gibson of Basic English fame. From this beginning evolved a participation-type system of training widely used today in industry for the improvement of employees' verbal skill in interpersonal relations.

Versatility, the Theme of PerceptoScope Design
F. E. VANDERWAL, *Perceptual Development Laboratories, St. Louis, Mo.*
Excerpts from a few of the industrial and educational training courses of the Perceptual Development Laboratories are used to demonstrate the PerceptoScope and to illustrate its abilities in the projection of 16mm film. A detailed discussion of three key design features of the PerceptoScope explain its unusual operation and how these features, plus imaginative usage, will get more out of 16mm film.

The "Sun Calculator," A Method for Predetermining the Approximate Compass Position of the Sun During the Day
JOHN P. BREEDEN, JR., *Ford Motor Co., Dearborn, Mich.*
The "Sun Calculator" consists of a set of three wallet-sized diagrams which graphically represent the position of the sun during daylight hours in relation to a central North-East-South-West plan. By its use the cameraman can determine for any season of the year what time of day the sun

will shine from the direction he desires, or if it will never shine from that direction. How to make and use the diagrams is explained.

The Challenge Facing the American Film Producer

HENRY USHIJIMA, *John Colburn Associates, Inc., Wilmette, Ill.*

The producers of both entertainment and commercial films are considered: the former must face the challenge of the home TV set and must create significant films for the motion-picture theater; and the commercial producer must make the client's problem his own problem and give to it not only his specialized abilities but also a lively and profound interest.

Analyzing the Commercial Applications of 16-mm Motion Pictures

ELY I. BERGMANN, *Universal Film Productions, Ltd., San Antonio, Tex.*

TUESDAY EVENING

8:00 PRESENTATION OF AWARDS

WEDNESDAY—OCTOBER 22

9:00 TELEVISION EQUIPMENT AND PRACTICES

On the Quality of Color-Television Images and the Perception of Color Detail

O. H. SCHADE, SR., *Electron Tube Div., Radio Corp. of America, Harrison, N.J.*

A theoretical and experimental study of the NTSC color system supported by color photographs shows that contrast range and color saturation obtained with commercial color kinescopes provide a larger color space than provided by color motion pictures. In fine detail more than 60% of full color information is transmitted and reproduced by the NTSC system, because the bandwidth restrictions of the electrical color signals (I,Q) do not affect definition in the vertical dimension and have a smaller effect on the reproduction of horizontal color detail than indicated by earlier evaluations which disregarded the two-dimensional nature of the image. The detail color reproduction appears adequate to the eye because the color errors remaining are small although perceptible. This fact is significant because the spatial sine-wave response functions of the color discriminators of the visual system are found to be substantially independent of the color of light and similar to the spatial sine-wave luminance response function of the eye.

Improved Vidicon Focusing and Deflecting Coils

J. CASTLEBERRY, *Industrial Electronic Products, Radio Corp. of America, Camden, N. J.*, and B. H. VINE, *Electron Tube Div., Radio Corp. of America, Lancaster, Pa.*

The effect known as "beam landing error" or "porthole" in vidicon cameras is eliminated through the use of a suitable coil configuration. The axial positions of the coils are chosen so that the beam electrons approach the target with only an axial component of velocity at all times. Exceptional signal uniformity, independent of signal electrode voltage and focus field strength, is then obtained with a vidicon having a uniform photoconductor. A particular coil design and the results obtained with it are discussed.

Design Trends in Television Lighting-Control Equipment

TOM C. NUTT, *Canadian Broadcasting Corp., Toronto, Ont., Canada*

Lighting-control systems have been designed which permit all TV lighting equipment to be readily assembled, and ultimately controlled by one technician located at a control console. The console design is such that the maximum number of lighting operations may be preset during rehearsals, and reproduced on air by simple direct switching. The education of the lighting technician to the operation of preset lighting-control systems is discussed and also the relationship of this type of control system to TV operations.

Television Zoom Lenses

GORDON HENRY COOK, *Taylor, Taylor & Hobson Ltd., Leicester, England*

The advantages to be gained in outside broadcast presentation by the use of camera lenses of variable focal length have been well established with the aid of lenses designed for that purpose. If similar advantages are to be provided under the different operating conditions encountered in the studio or in industrial TV, new types of lenses with more extreme optical characteristics are necessary. The solution of these new optical problems yields a zoom lens ideally suited for a wide variety of TV applications.

Transistorized Auricon Camera

EDWARD M. TINK, *WLAC-TV, Inc., Nashville, Tenn.*

A sound-on-film recording system has been made of a portable power supply and a miniature transistor amplifier mounted directly on the side of an Auricon 16mm Camera. The power supply is housed in a standard camera gadget bag and supplies both a-c power to the camera drive motor and d-c power to the amplifier and exposure lamp. Nickel-cadmium cells and a built-in charger virtually eliminate battery replacement. The entire system weighs 36 lb.

The Victor Multicolor Televisor

ALEXANDER F. VICTOR, *Alexander F. Victor Enterprises Inc., Carmel-by-the-Sea, Calif.*

A method for producing color on existing black-and-white TV receivers, which does not require electrical or mechanical changes in the sets, is described. The system includes a projector for

AUTOMATIC TRI-FILM PROCESSOR

UP TO SIX FEET A MINUTE WITHOUT LOSS OF QUALITY!

THE transportable Mark 3 Automatic Tri-Film Processor develops and dries 16, 35 or 70 mm. film at 1½, 3 or 6 feet a minute! Four 400-ft. 16 mm. films can be handled simultaneously—or two 400-ft. 35 mm films—or one 400-ft. 70 mm length. The various film sizes are accommodated by simple adjustments of film separators. Separate temperature control of the processing solution is possible on each tank from 60 to 110 degrees F., within ± 1 degree. The latest high temperature chemical resistant plastics and Type 316 stainless steel are used in all chemical areas. Processing is controlled by a mechanical program unit after the film is loaded into the machine—no special "leader" or continuous tapes, chains or sprockets are used.

The need for stop baths and interbath rinses, normally required in many processes, is virtually eliminated because of a positive squeegee roller design.

A high-efficiency blower system and electrical heating ensure rapid drying in the machine. The Processor is perfect for newsreels, TV news on film, motion picture "rushes" in the field,—in all cases where speed plus quality are essential. Write for literature and quotations.

SPECIFICATIONS

AUTOMATIC TRI-FILM PROCESSOR TYPE T246 Mk3

Size	54" long, 22" wide, 51" high
Weight	400 lbs
Power Consumption	5 KVA maximum single-phase 110 volts 45 amps or according to customer requirements
Process Capacity	1 to 4 rolls 16 mm / 1 or 2 rolls 35 mm / 1 roll 70 mm — length to 400 ft.
Rate of Processing	1½, 3 or 6 ft. per min.

Temperature-controlled solutions and dryer. Daylight operation except loading of film into magazine. Processes perforated or plain film.

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Canadian Applied Research Limited

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TORONTO 16, ONTARIO, CANADA
PLYMOUTH

MEMBER: A. V. ROE CANADA LIMITED & HAWKER SIDDELEY GROUP

broadcasting stations to transmit color pictures to existing black-and-white receivers and a multicolor screen for the reception of the pictures.

New Eidophor System for Large Screen Projection of TV

EDGAR GRETENER, *Gretener A.G., Zurich, Switzerland*

The Eidophor, a system of projecting television pictures on motion-picture screens, was invented 20 years ago by the Swiss scientist, Fritz Fischer. After his death in 1947, development of the system was continued at the Dept. of Industrial Research, Swiss Federal Institute of Technology, Zurich. Simplification of the original system was achieved by the introduction of a mirror system for schlieren optics. The present compact (2 ft by 5 ft by 3 ft) Eidophor was brought to its present stage of development by Gretener A.G., which took over the system in 1951. The Gretener organization then entered into an agreement with 20th Century-Fox Film Corp. which, under terms of the agreement, is developing a wide-screen color Eidophor. The black-and-white system can project a 15 ft by 20 ft image. An important feature is its ability to operate using a relatively low-power xenon gas lamp as the light source. The system is a complete receiver-projector unit and can be connected to a TV antenna for standard broadcast reception or to closed-circuit wires.

WEDNESDAY AFTERNOON

1:30 A NEW LOOK AT FILM TECHNIQUES IN TELEVISION

Effective TV Commercials — Some Fundamentals

HORACE S. SCHWERIN, *Schwerin Research Corp., New York*

Based on audience tests of about 10,000 commercials, there is summarized what has been learned through use of the Schwerin Competitive Preference technique in regard to the characteristics of effective and ineffective commercials. The paper concentrates on so-called "independent" commercials (i.e., those that are not integrated into programs), and also deals more briefly with some fundamentals in regard to personality-delivered TV advertising.

The TV Workshop: A Unique Agency Client Service

WARREN G. SMITH, *J. Walter Thompson Co., New York*

The showing of a 15-min sound film, after an introduction by the author, guides the viewer through the JWT Company TV Workshop. First the nontechnical features, then the workshop facilities and their employment are covered. Live and film television, both monochrome and color, live film, animation and kinescopes, sound recording—all are treated in the film and accompanying paper in sufficient detail to allow thorough understanding of how and why the Workshop functions.

Television Film Commercial Production in New York City

WILLIAM H. UNGER, *Elliot-Unger-Elliot Motion Pictures, New York*

The main requirement for satisfactory commercial production of TV films is flexibility of operation; the major problem in achieving this flexibility is lack of space. Some of the mechanical facilities of a small studio can be designed to expedite day-to-day production, and also production techniques have been evolved around these facilities.

Fifth U.S. Army TV Hometowner Project

DAVID B. ANDRE, Chief, and PFC HOWARD CHAPMAN, Producer, *Radio-TV Branch, Information Section, Headquarters, Fifth U.S. Army, Chicago*

The Department of the Army initiated a "Hometown TV Film Program" in late 1957. A "TV Hometowner" is a 60–90 sound-on-film action sequence or interview featuring Army personnel in training and on the job at Fifth U.S. Army posts and camps in the Middle West and western Great Plains region, for distribution to hometown TV stations in all parts of the country. A TV team composed of a producer and cameraman, using Auricon pro-600 sound camera, a Zoomar lens and professional sound equipment, has completed over 500 TV interviews and features since January 1958. The film is processed and mailed to TV stations by the Army Home Town News Center in Kansas City, Mo.

Filming for Educational Television

DAVID W. JOHNSON, *University of Southern California, Los Angeles*

The varied subject matter of educational TV programming dictates a flexible approach to filming. The techniques differ from those used in commercial TV filming in that they must meet individual situations as they arise, with no sacrifice in quality. Further, the budget for an educational program is frequently less than one-twentieth that of a commercially filmed program of the same length produced by comparable techniques. The Staff Production Unit of the University of Southern California, Department of Cinema, has produced four series, totaling 44 half-hour programs for educational TV. Each series had unique production problems which called for different solutions. These problems are discussed and short samples shown.

Aspects of Kinescope Recording Evaluation

KEITH K. KETCHAM, *WOI-TV, Iowa State College, Ames, Iowa*

The various aspects of kinescope recording practices are particularly related to the making of kinescopes for Educational Television and Radio Center by various educational suppliers. Definite methods of evaluating kinescope recordings are analyzed as a guide toward establishing a more

complete, workable set of standards. Present methods do not provide absolute procedures to assure optimum results.

The Role of Black-and-White Film in Color Television

WILLIAM L. HUGHES, *Electrical Engineering Dept., Iowa State College, Ames, Iowa*

In discussing the economics of black-and-white film systems for use in color TV, particular stress is placed on the advantages for program syndication and for commercial and news production. The general cost breakdown for the newly announced Iowa State College system is presented from the standpoints of the station operator and the syndicated film producer. The physical and operating characteristics of the system are outlined.

WEDNESDAY EVENING

6:45 Cocktail Party

8:00 BANQUET AND DANCE

THURSDAY—OCTOBER 23

10:15 KINESCOPE RECORDING PROBLEMS AND EQUIPMENT

The Marconi 16mm Fast Pulldown Kinescope Recorder

M. E. PEMBERTON, *Canadian Marconi Co., St. Laurent, P.Q., Canada*

The object of the recording channel is to produce a standard 16mm film. The Recording Monitor, which produces the high-quality TV picture, and the 16mm Fast Pulldown Camera, which is used to record the TV picture, are described. Performance data are given and a typical film made with this equipment is shown.

A New Low-Cost and Practical Kinescope Recorder

WILLIAM O. CRUSINBERRY, *Dage TV Div., Thompson Products, Michigan City, Ind., and*
LESLIE P. GREENHILL, *The Pennsylvania State University, University Park, Pa.*

The need for a low-cost, reliable and easily operated kinescope recorder will be discussed and illustrated. The electrical and mechanical characteristics of the Dage KR11 Kinescope Recorder will be described and the problems involved in its development will be discussed. Methods of setting up operating procedures and standards, film-processing requirements and quality-control procedures will be described with reference to the use of the recorder with vidicon TV camera chains. Educational applications will be indicated and illustrated with the showing of a short sample kinescope recording.

Emulsion Sensitivity for the Photography of Cathode-Ray Tubes

R. W. TYLER and F. C. EISEN, *Kodak Research Laboratories, Eastman Kodak Co., Rochester, N.Y.*

Properties of a P11 phosphor which affect photographic exposure have been investigated. Decay rate of phosphorescence was found to increase with spot velocity. Writing rates for several emulsions were determined for an oscilloscope and were found to rank emulsions in the same order as sensitometric tests made by exposing emulsions through a density step tablet to filtered tungsten and xenon flash illuminants. The effect of forced development is described.

Synthetic Highs — An Experimental TV Bandwidth Reduction System

W. F. SCHREIBER, C. F. KNAPP and N. D. KAY, *Technicolor Corp., Burbank, Calif.*

This paper describes a complete experimental system which codes a standard video signal to match a narrow-band channel and subsequently decodes the received signal for display on a standard TV monitor. The system transmits the low frequency, or macrocontrast signal, in analog form. The location and quantized amplitude of the edges are transmitted by a digital code. Bandwidth reduction is achieved by exploiting both statistical correlations and psychophysical phenomena. Apparatus for the separation of low frequencies, detection and quantization of edges, and synthetic reconstruction of highs are described. Kinescope photographs of the resulting pictures will be shown. Factors affecting the degree of bandwidth reduction will be discussed, as will the effect of variation of system parameters such as separation frequency and quantization levels.

THURSDAY AFTERNOON

1:30 MACHINE LANGUAGE TRANSLATION and INTERNATIONAL TELEVISION

Automatic Printed Character Reading

BOWMAN SCOTT and P. A. M. CURRY, *Solartron Electronic Group Ltd., Surrey, England*

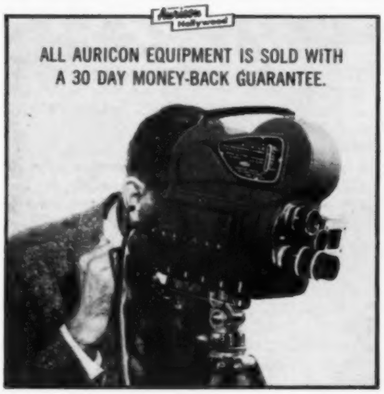
There is a need for automatic character recognition in business data processing systems and a particular method of reading has been chosen. A description of the method also points out the facilities for overcoming the defects of ordinary typescript. The future program is outlined with a view to the eventual contribution toward automatic translation.

The BBC Television Standards Converter

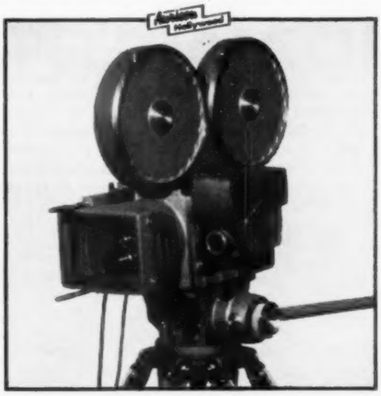
T. WORSWICK, *British Broadcasting Corp., London, England*

After outlining the background of the standards conversion problem in European TV, the design

AURICON 16mm Sound-On-Film for Professional Results!



"CINE-VOICE II" 16 mm Optical Sound-On-Film Camera. ★ 100 ft. film capacity for 2¾ minutes of recording; 6-Volt DC Convertor or 115-Volt AC operation. ★ $795.00 (and up).



"AURICON PRO-600" 16mm Optical Sound-On-Film Camera. ★ 600 ft. film capacity for 16½ minutes of recording. ★ $1871.00 (and up) with 30 day money-back guarantee.

"SUPER 1200" 16 mm Optical Sound-On-Film Camera. ★ 1200 ft. film capacity for 33 minutes of recording. ★ $5667.00 (and up) complete for "High-Fidelity" Talking Pictures.

SOUND RECORDER—Model RM-30 ... 1200 foot film capacity, synchronous motor for "double-system" 16mm Optical Sound-On-Film operation. ★ $3630.55 (and up)

PORTABLE POWER SUPPLY UNIT—Model PS-21 ... Silent in operation, furnishes 115-Volt AC power to drive "Single System" or "Double System" Auricon Equipment from 12 Volt Storage Battery, for remote "location" filming. ★ $269.50

FILMAGNETIC—Finger points to Magnetic pre-stripe on unexposed film for recording lip-synchronized magnetic sound with your picture. Can be used with all Auricon Cameras. ★ $870.00 (and up)

TRIPOD—Models FT-10 and FT-10S12 ... **Pan-Tilt Head Professional Tripod** for velvet-smooth action. Perfectly counter-balanced to prevent Camera "dumping." ★ $406.25 (and up).

Strictly for Profit

CHOOSE AURICON

If it's profit you're after in the production of 16 mm Sound-On Film Talking Pictures, Auricon Cameras provide ideal working tools for shooting profitable Television Newsreels, film commercials, inserts, and local candid-camera programming. Now you can get Lip-Synchronized Optical or Magnetic Sound WITH your picture using Auricon 16 mm Sound-On-Film Cameras. Precision designed and built to "take it."

Strictly for Profit—Choose Auricon!

AURICON

BERNDT-BACH, INC.

6946 ROMAINE ST., HOLLYWOOD 38, CALIF.

Auricon Hollywood

Auricon Equipment is sold with a 30-day money-back guarantee. You must be satisfied.

Please send me free Auricon Catalog. 6946A

Name..

(Please write your address in margin)

MANUFACTURERS OF SOUND-ON-FILM RECORDING EQUIPMENT SINCE 1931

and performance of the British Broadcasting Corp. standards converter are described. This converter comprises a high-quality display of the incoming (625- or 819-line) picture which is presented to a TV camera using a 4½-in. image orthicon pickup tube (P812) on the British standard of 405 lines.

Status of Machine Translation Research at Georgetown University
LEON E. DOSTERT, *Georgetown University, Institute of Languages and Linguistics, Washington, D.C.*
A brief review is given of the principal aspects of the three approaches to machine translation developed at Georgetown for the translation of Russian and French into English. Approaches to the resolution of lexical, structural, and semantic ambiguity, and the research methodology followed in the three approaches are described. The nature and results of the test of the "Code Matching Technique," Aug. 20, 1958, are discussed.

Impressions of Electronics in Russia
By AXEL G. JENSEN, *Bell Telephone Laboratories Inc., Murray Hill, N.J.*
Highlights of two trips to Russia where the author had an unusual opportunity to observe the television industry will be described and illustrated with Kodachrome slides of photographs taken in Moscow and Leningrad. The first trip was made in 1957 when the author attended a meeting of the Popov Society as an IRE delegate. At that time he visited factories and scientific institutes and discussed the development and progress of television in the U.S.S.R. with Soviet scientists. In 1958 he returned to Moscow as a U.S. delegate to a Study Group on Television of the International Radio Consultative Committee. An especially interesting observation is in regard to the progress of color TV during the interval between his visit in 1957 and his return in 1958.

Video Time-Delay Systems
CHARLES P. GINSBURG, *Ampex Corp., Redwood City, Calif.*
The need for an improved means for conversion of TV programs from the frame and line standards of one country to those of a different country is well known in the industry. In the course of video-tape recording research, certain techniques have been developed for storing various intervals of TV information. It may be possible, by the use of some of these techniques, to devise a solution for the standards conversion problem.

A Study of Factors Influencing the Visibility of Televised Materials
WARREN F. SEIBERT, *Audio-Visual Center, Purdue University, Lafayette, Ind.*
Thirty six volunteer subjects, screened for normal visual acuity, viewed televised displays during a one-hour testing session. There were 252 displays; each consisted of four characters (letters and numbers) of a given size and contrast condition. The study design made it possible to compare visibility across: (1) six viewing distances, (2) three viewing angles, (3) three figure-background contrasts, (4) four character sizes, and (5) three time blocks within the testing session. Results indicate that no visual fatigue occurred, that black on white and white on black contrasts produced about equal visibility, and that characters subtending ten minutes of vertical visual angle could be perceived with almost complete accuracy.

THURSDAY EVENING

7:45 CLOSED-CIRCUIT TELEVISION FOR TEACHING

Educational Television Today
C. M. BRAUM, *Joint Council on Educational Television, Washington, D.C.*
Following upon the policy of reservation of channels for noncommercial educational television broadcasting, stations have been established and programming services provided. A number of organizations are involved in the planning, operation and programming of these stations. Closed-circuit TV for instruction in colleges and schools has also been developed. Present plans and indications for further growth of open- and closed-circuit educational TV are discussed.

Color and Monochrome Closed-Circuit Television at a Large University
FREDERICK M. REMLEY, JR., *University of Michigan, Ann Arbor, Mich.*
Three independent TV facilities are now in operation on the campus of the University of Michigan. Each installation meets specific needs and each is equipped and designed differently. The reasons for the establishment of the two monochrome studios and the one color studio are explained, and the proposed expansion of facilities is described.

Closed-Circuit Television in Hagerstown
JOHN R. BRUGGER, *Washington County Board of Education, Hagerstown, Md.*
Inaugurated in Hagerstown, the experimental use of closed-circuit TV in schools in Washington County, Md., is now in its third year. Organized as a five-year project, the general design of the system and equipment and the operation of the program are covered as a report of progress since earlier reports presented before the Society.

Administrative-Operational Problems of Medical Color Television
LOUIS W. CRIST, *Smith Kline & French Laboratories, Philadelphia*
The growth and development of the Smith Kline & French Medical Color Television Unit since

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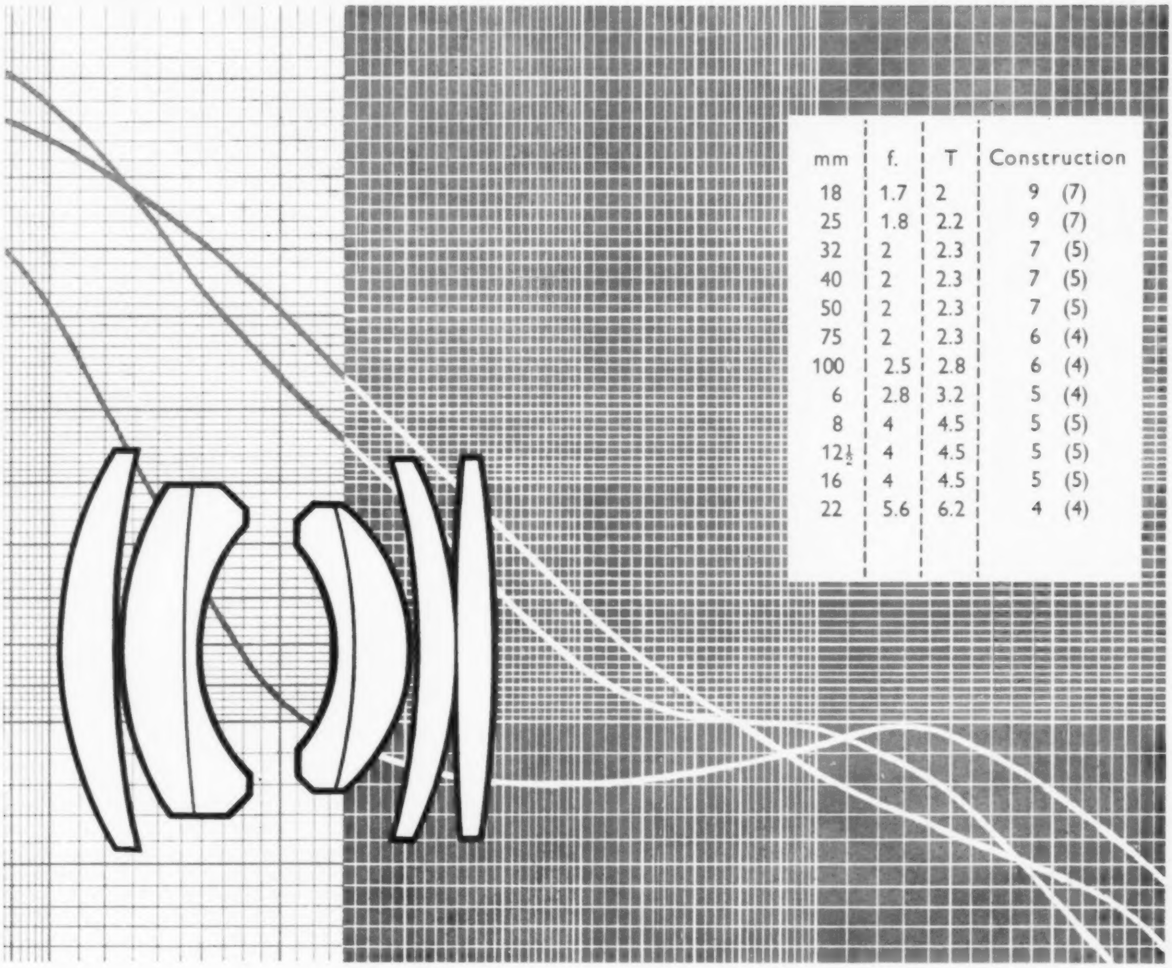

mm	f.	T	Construction
18	1.7	2	9 (7)
25	1.8	2.2	9 (7)
32	2	2.3	7 (5)
40	2	2.3	7 (5)
50	2	2.3	7 (5)
75	2	2.3	6 (4)
100	2.5	2.8	6 (4)
6	2.8	3.2	5 (4)
8	4	4.5	5 (5)
12½	4	4.5	5 (5)
16	4	4.5	5 (5)
22	5.6	6.2	4 (4)

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its first program in 1949 is traced. The advisability of future installations of permanent color TV facilities in major medical teaching centers is critically appraised in the light of the history of such installations and SKF's own experience. Emphasis is on the problems rather than the better-known advantages of such installations, and solutions to the problems are suggested.

Exchange of Air Defense Information by Closed-Circuit Television
Lt. Col. HOLLIS DAKIN, *U.S. Army Pictorial Center, Long Island City, N.Y.*
A new type of studio vidicon camera has been tested on a closed-circuit microwave TV system. The equipment, personnel and techniques are described as used for the immediate exchange of radar plotting information between Army and Air Force Defense Installations in Norfolk and Cape Charles, Va.

FRIDAY—OCTOBER 24
9:00 SOUND SESSION, GENERAL MOTORS PHOTOGRAPHIC, 464 W. Milwaukee Ave.

The Soundtrack in Nontheatrical Motion Pictures
FRANK LEWIN, *Filmsounds, Inc., New York*
The functions of the three components of the soundtrack—voice, music and sound effects—are discussed with detailed guides for editing them. The preparation of soundtracks for re-recording is described. Procedures are suggested to facilitate mixing.

A Method of Recording, Editing and Mixing Magnetic Sound for Industrial Films
DONALD A. ANDERSON, ROBERT H. WINTER and REID H. RAY, *Reid H. Ray Film Industries, Inc., St. Paul, Minn.*
Methods of recording, editing and mixing live dialogue, effects and music in industrial film production vary greatly. This paper outlines one method and describes the conversion from optical sound equipment with a minimum of new equipment to all-magnetic sound used in recording, editing and mixing. Parallel techniques are followed using 35mm soundtracks whether the photography is 16 or 35mm. Seven steps are described from the original 35mm magnetic recording until the transfer to either 16 or 35mm optical sound negatives.

A Method of Minimizing Exposure Drifts in Film Recorders
GEORGE LEWIN, *Army Pictorial Center, Long Island City, N.Y.*
Serious drifts in exposure have been encountered when making long re-recorded negatives for release printing. These drifts are especially noticeable when using the 35/32mm method where the total recording time may be as high as one hour. Possible causes of this problem are discussed and a method of minimizing it is described.

A New Approach to Magnetic Half-Striping of Optical Tracks
MAXWELL A. KERR, *Melpar, Inc. (A Subsidiary of Westinghouse Air Brake Co.), Falls Church, Va.*
A new method of adding magnetic striping without losing optical playback is explained and demonstrated. Advantages over present half-striping are: reduction of distortion during optical playback; higher signal output from optical track; elimination of critical alignment of striping machinery with centerline of optical track; reduction of optical track scratching by magnetic playback head; ability to play back two channels of magnetic sound as well as optical track; more even distribution of headwear during magnetic track playback; can be added to old films with the original unilateral variable-area track as well as to presently used optical tracks.

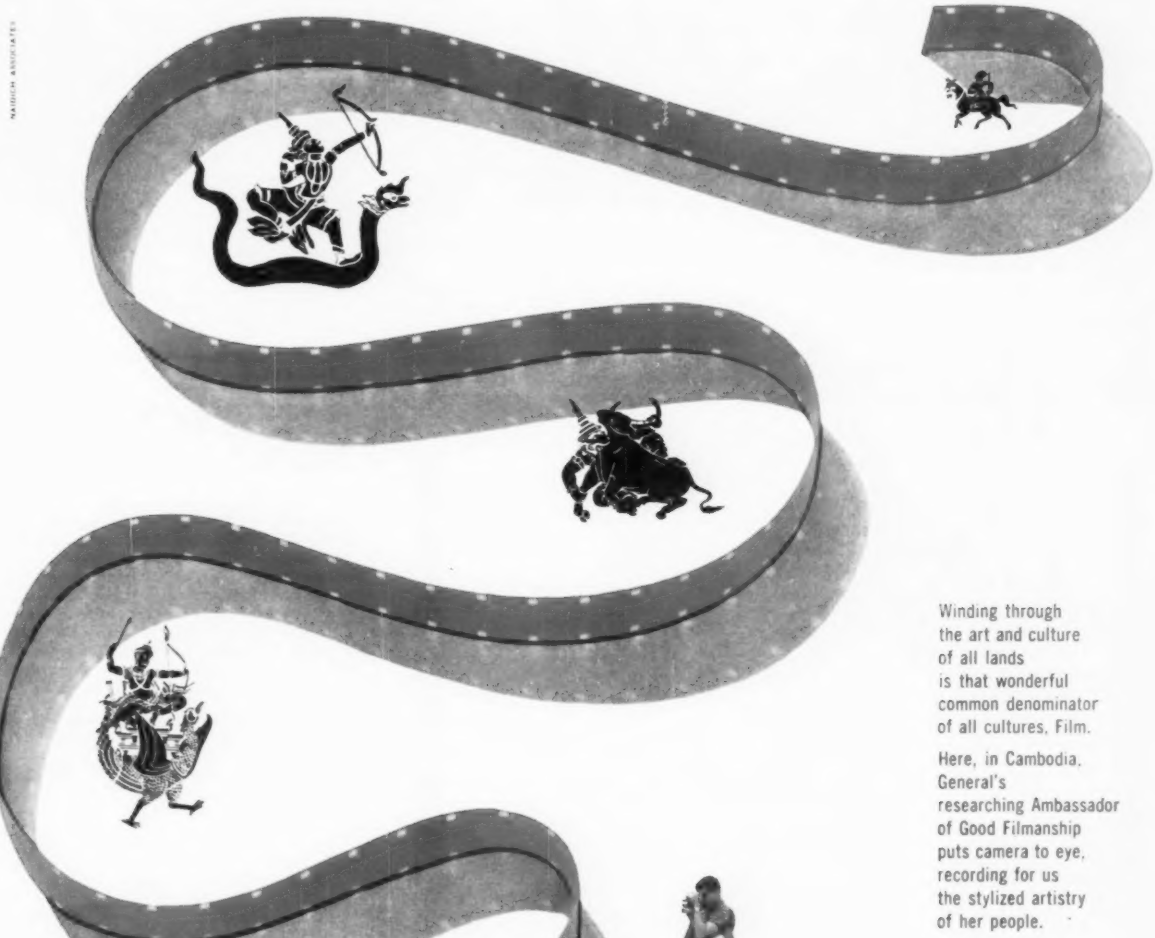
Single-System Editorial Synchronism Using Magnetic Soundtrack
ELLIS W. D'ARCY, *D'Arcy Magnetic Products, Inc., Gary, Ind.,*
Editorial synchronism in picture taking and release prints has been considered desirable since the beginning of sound pictures. For economical rapid film production of the news, documentary and training films, this objective can be achieved by means of prestriped magnetic picture taking stocks and an instantaneous soundtrack relocating re-recorder. This technique has been developed and a universal magnetic professional recorder designed for the purpose.

A Multichannel Selective Program Repeater Utilizing the New Mackenzie Continuous-Loop ¼-in. Magnetic Tape Magazine
LOUIS G. MACKENZIE, *Mackenzie Electronics, Inc., Inglewood, Calif.*
This paper covers the design and operation of an endless-loop ¼-in. magnetic tape magazine with uniform low-friction tape motion for precision applications and a five-channel selective program repeater. The salient features include high-speed solenoid actuation for instantaneously cued stop-start operation, and completely transistorized audio and control circuitry. The paper also describes pertinent applications in the film recording, television, radio broadcasting and allied industries.

FRIDAY AFTERNOON

1:15 STANDARDS AND STANDARDIZATION

Projector Noise Levels
G. E. WHITNEY, M. T. BUCKELEW and J. F. McGRANE, *American Machine and Fdry. Co., Alexandria, Va.;* M. L. BARON, *Signal Equipment Support Agency, Fort Monmouth, N.J.*
Analyses and empirical tests have been made to determine optimum noise levels of photographic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projectors. It is shown that to achieve 96% intelligibility (per cent of sentences understood) the projector should have an "articulation index" greater than 0.4, a quantity related complexly to noise and frequency. The index is simple to determine when the projector noise spectrum parallels the spectrum for ordinary speech, i.e., when it peaks near 500 cycles/sec. Measurement of the index is more difficult when the spectra are nonparallel.

SMPTE Contributions to Standardization in the U. S.
FREDERICK J. KOLB, JR., *Eastman Kodak Co., Rochester, N. Y.*

International Standardization of Magnetic Sound on Film — A Status Report
M. G. TOWNSLEY, *Bell & Howell Co., Chicago*
Standardization of frequency characteristics of magnetic sound on motion-picture film has been on the program of ISO TC/36, Cinematography, for several years. At Stockholm in 1955 tentative agreement was reached on a frequency characteristic and a method of measurement. Later developments led to a disagreement on frequency characteristic, particularly in 16mm, and to a change in concept in the method of measurement. At Harrogate in 1958 a new agreement was reached, in which the frequency characteristic is given with tolerances which include both American and European practice and in which the frequency characteristic is specified in terms of relative levels to be recorded on the film.

International Standardization for Motion Pictures and Films for Television
DEANE R. WHITE, (*Leader, U.S. Delegation to the Harrogate Meeting of ISO/TC36*), *E. I. du Pont de Nemours & Co., Inc., Photo Products Dept., Parlin, N.J.*
The third meeting of ISO/TC 36, the committee responsible for development of international standards for motion pictures, was held in June 1958. Attention was given to problems arising from both television and theatrical usage. Areas of mutual understanding and agreement were enlarged. Improvement in the ease of international exchange of theater and television program material is the predictable result of this work.

INSTRUMENTATION AND HIGH-SPEED PHOTOGRAPHY

Techniques in High-Speed Microphotography
R. WAYNE ANDERSON, *Photographic Dept., Dow Chemical Co., Midland, Mich.*
The developments and techniques used by recognized authorities in the field of high-speed microphotography are reviewed. Slides and motion pictures illustrate micro studies obtained by using cameras that have been adapted or developed to resolve specific problems in micrography. Continuous and intermittent light sources are described as used in high-speed still and cinemicrography studies.

Shutter Image Converter Tube for Multiple Frame Photography
WILLIAM O. REED and WILFRID F. NIKLAS, *The Rauland Corp., Chicago*
Various systems for ultra-fast photographic shutters are described. It is shown that Shutter Image Converter Tubes have the advantage of light gain and the adjustable frame rate and frame spacing. A shutter tube is described which is capable of delivering 16 frames on the viewing screen, utilizing electrostatic focusing and electromagnetic deflection. This tube employs an Sb-Cs (0) photocathode formed by external Sb-evaporation, a cascaded focusing system, deflection yokes which are assembled around the neck of the tube, a lumped PDA system, and a yellow-green modified P20 phosphor for the viewing screen. The tube is capable of exposure times in the range of 1 millimicrosecond.

Color Exposure for High-Speed Photography of Some Events Requiring Artificial Illumination
KARL-HEINZ LOHSE, *U. S. Steel Corp., Monroeville, Pa.*

Education, Industry News

A recording-reproducing color television system which puts color electronically on 35mm black-and-white film has been developed at Iowa State College, Ames, Iowa. The system is described as completely compatible with all current television standards and the film may be used to rebroadcast or reproduce the original color. Simplicity is noted as an outstanding feature of the ISC system. It is said to be less complicated and more economical to operate than the simplest black-and-white film chain and is designed to be operated by the average studio technician. The equipment is on display at the Electrical Engineering Building on the ISC Campus. It was first demonstrated on Sept. 17, 1958, and thereafter will be demonstrated from 10 AM to 4 PM on Oct. 1, 16, 17, 24 and 25.

A paper on the system, "Recent Improvements in Black-and-White Film Recording for Color Television Use" by William L. Hughes, appeared in the July 1956 *Journal*, pp. 359-364. Mr. Hughes presented at the Washington Convention in 1957 a paper "Some Theoretical Aspects of Storing Color Television Information on Black-and-White Film" which has appeared as Iowa State College Bulletin 180.

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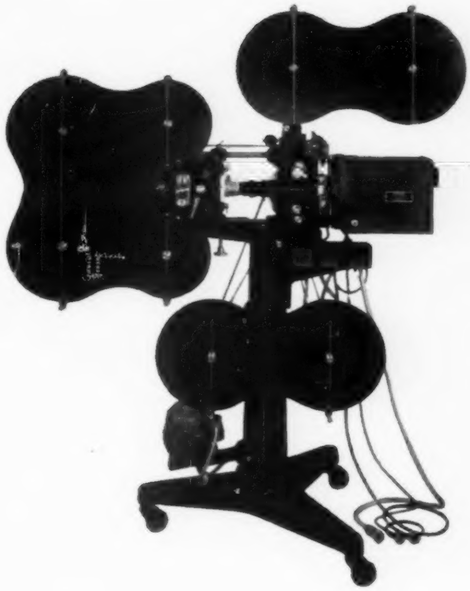

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The Flying Angel, a color short subject produced by Unusual Films of Bob Jones University, has been selected as a United States entry in the 1958 Edinburgh Film Festival, Aug. 24 to Sept. 14. Selection was made by the Committee on International Nontheatrical Events of the Dept. of Audio-Visual Instruction, National Education Assn. The film portrays the University's motion-picture production and training facilities. Produced by students under faculty supervision, the film shows student and staff technicians building scenery, designing and constructing costumes, applying motion-picture make-up, shooting original film, and editing the picture footage and sound recordings which go in the finished product.

A Film Festival and Audio-Visual Exhibit was held May 27 at the William Samuel Johnson School, Bridgeport, Conn. The Festival was sponsored by the Dept. of Visual Education, Bridgeport Public School System, and was under the direction of John D. Del Vecchio, Acting Director of Visual Education. There were 21 exhibits of audio-visual materials and equipment.

An American Film Festival will be held at the Statler Hotel, New York, April 1–4, 1959, under the auspices of the Educational Film Library Assn. Sound and silent filmstrips and 16mm films in educational, cultural, religious, medical and industrial fields will compete for Blue Ribbon Awards which will be presented to approximately 25 category winners. The Festival is an expansion of the EFLA program of film appraisal and evaluation. Although more than 3600 films have been rated by the EFLA Evaluation Project, the Association has not previously made awards. Any nontheatrical films and filmstrips released in the United States during the calender years 1957 and 1958 will be eligible for awards in the 1959 Festival.

The site of the new CBS Laboratories Research Center at Stamford, Conn., has been increased by 12 acres to make 23 acres in all. The Research Center will encompass research and development activities in the fields of military reconnaissance systems, acoustics, solid state and vacuum physics, magnetics, high-resolution data, recording systems and related work. The building is a glass-enclosed aluminum and steel structure with an open-air inner court in the center of the building. Architects are Skidmore, Owings & Merrill. Opening of the Center is scheduled for this fall when the present headquarters of the Laboratories in New York will be moved to Stamford.

Canadian Kodak Co. Ltd., Toronto, Ontario, an affiliate of Eastman Kodak Co., has announced construction of a $1 million building to house all finishing operations in the production of photographic paper. The two-story building, scheduled for completion in the summer of 1959, will have a floor area of approximately 50,000 sq ft. During the last five years, the company has been engaged in a $5 million expansion program.

Howard W. Hoadley, Manager, Motion-Picture and Still Depts., Marquardt Aircraft Co., Van Nuys, Calif., has been appointed Editor of the quarterly News Bulletin of the Society of Photographic Scientists and Engineers. The announcement was made by George T. Eaton, SPSE President.

Arthur H. Bolt, who has been associated with Bell & Howell for 29 years, has accepted appointment to the post of Vice-President for Engineering and Production for Traid Corp., Encino, Calif. During his association with Bell & Howell he held a variety of management positions, the most recent being Asst. Vice-President of West Coast Operations. Traid Corp. is special representative for Bell & Howell in the Western United States for photographic instrumentation cameras for military use.

Adrian Woolery, President of Playhouse Pictures, 1401 North La Brea Ave., Hollywood 28, specialists in animation, has been chosen as contributing writer for *The Technique of Film Animation.* This book is sponsored by the British Film Academy and is scheduled for fall publication by Focal Press in England and Hastings House in New York.

Murder on the Screen, a 16mm film on the subject of cause and prevention of film damage, has been produced by Eastman Kodak Co. and is available on a loan or lease arrangement. The film is in


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color and sound. Running time is 22 min. The film depicts techniques described in *Prolonging the Life of the Motion-Picture Film* by E. C. Johnson, published in this issue of the *Journal* (pp. 590-592). Arrangements to borrow or lease the film may be made with the Motion Picture Film Dept., Eastman Kodak Co., at any of the following addresses: 343 State St., Rochester 4, N.Y.; 342 Madison Ave., Suite 626, New York 17; 130 E. Randolph Dr., Room 2006, Chicago 30; 6706 Santa Monica Blvd., Hollywood 38.

The closed-circuit TV installation at Walter Reed Army Medical Center is the subject of an article reprinted by RCA and distributed with the August 1958 issue of the *RCA Educational TV News* as a special service to educators. The article, "Walter Reed Army Medical Center Uses RCA Compatible Color Television for Medical Education," describes the installation which was completed late in 1956.

Shortly after the installation was completed, members of the Society who attended the 1957 Spring Convention in Washington, D.C., had the opportunity of observing the system at work during a guided tour and demonstration arranged by officials in charge of the program. A session was devoted to papers presented by staff members of Walter Reed Hospital who discussed various aspects of the closed-circuit program which was then opening up a whole new field in medical science. Among the speakers who presented papers were Paul W. Schafer, M.D., Television Div., Walter Reed Army Medical Center; Julius Halsman, Medical Illustration Service, Armed Forces Institute of Pathology; Ralph W. Curtis, Walter Reed Army Medical Center; and George A. Baker, Television Div., Walter Reed Army Medical Center.

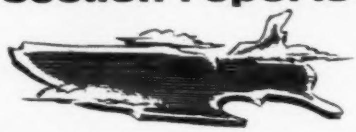
A few highlights of the RCA article are quoted below: "The Walter Reed system . . . contains the first Medical Color TV Camera designed for ceiling mounting in operating and autopsy rooms. It also includes a specially designed color TV system of microscopy utilizing standard instruments . . . . For use in color TV microscopy there has been developed a television microscope assembly. This utilizes an RCA 3-V color camera . . . suspended in such fashion as to insure alignment with the optical system of the several microscopes employed . . . . The ultimate capacity of the (TV) Division is difficult to ascertain. However, it is expected that this point will be reached during fiscal year 1958 and that it is approximately 150 to 200 programs per month . . . . (An) organization of this magnitude . . . represents an implementation of the conviction that television is an effective and potent force in support of the training and education mission of the Army Medical Service. This conclusion was reached after substantial deliberation by several committees of qualified experts representing all of the interested agencies. . . ."

The University of Miami, Coral Gables, Fla., has issued its 11th Annual Report on Broadcasting and Film Activities to cover the 1957–58 fiscal year. Twenty-four courses in Radio, TV and Film were taught during the first semester for a total of 59 credits, and 18 courses were taught the second semester for a total of 52 credits. During the year the University's film services were expanded with more than a half-million feet of film printed. The University is installing kinescope facilities, operated cooperatively with WTHS-TV, which is nearing completion.

Darkroom Design and Construction (No. K-13), published by Eastman Kodak Co., is a 64-page book intended for use as a guide in making preliminary plans for a darkroom. Topics discussed include: the expected work output, the number of people who will be working in the space; major pieces of equipment to be installed; available space; and the physical flow of work through the area. A section of 29 layouts is presented as examples of typical situations that might be encountered by a photography department in planning its facilities. The booklet is priced at 50 cents and is available at Kodak dealers.

A Kodak booklet, *16mm Kodak Movie Films — Data and Selection,* provides data for proper selection of 16mm film for various uses. One section gives complete exposure information, including exposure compensation when using filters. A suggested light-source-and-filter combination table is included for use with Kodachrome films. The booklet is available without charge from Eastman Kodak Co., Sales Service Div., Rochester 4, N.Y.

section reports



The Canadian Section entertained 55 members and guests at its Apr. 15 meeting, which took place at Caldwell's Queensway Studio, 1640 Queensway Ave., Toronto.

The first speaker was Glenn Robitaille, Chief Engineer of CFPL-TV, London, Ont., who spoke on "Film Telecasting from a Private Television Station — Its Implications and Its Problems." The subject of film was discussed from the point of view of an independent TV film user as opposed to a Canadian Broadcasting Corp. network origination point. Also described were the great differences in density and contrast of films received for projection. Mr. Robitaille commended the Lab Standards Committee of the Canadian Section for its work, remarking that he felt that its efforts would soon be rewarded by a more uniform quality in films for television use.

During the second half of the meeting, Robert Franz of Film Graphics, Inc., New York, spoke on "Motion Picture Optical Effects." After discussing film opticals, Mr. Franz outlined what optical effects could be performed by the new branch of his company, at their recently opened Toronto branch.—*Ronald E. Ringler,* Secretary-Treasurer, Du Pont Co. of Canada, Ltd., Toronto, Ont., Can.

Obituaries

Emmett K. Carver

Dr. Emmett K. Carver, prominent for many years in the affairs of the Society of Motion Picture and Television Engineers, died suddenly July 26, 1958. His active career covered four decades in the field of science, distinguished by university research, teaching, and industrial research and development.

Dr. Carver was a faithful attendant of SMPTE conventions, published several papers in the *Journal*, and took an active part in the affairs of the Society, particularly those having to do with engineering standards. He was a member of the Standards Committee from 1935 to 1953 and of the Film Dimensions Committee from 1949 to 1957, serving as committee chairman from 1949 to 1953. His contributions to both the philosophy and the engineering details of Society standards provided a leadership which spanned years of outstanding progress in the framing of standards for the motion-picture industry.

Dr. Carver was employed as a chemist at Kodak Research Laboratories in 1924. He organized the Kodak Park Manufacturing Experiments Division and was named its superintendent in 1928. In 1931, and again in 1939, he visited the Kodak plants in London, Paris and Berlin in connection with the film manufacturing departments. He was appointed Technical Assistant to the General Manager of Kodak Park in September of 1947.

During World War II, Dr. Carver was in charge of two projects at Kodak Park under the National Defense Research Council. One was connected with fuels for flame throwers and incendiary bombs and the other with research for a substitute for the rubber face-pieces of civilian gas masks. He served at the time of his death on one of the subcommittees of the Chemical Corps Advisory Council.

Born in Leando, Iowa, July 9, 1893, Dr. Carver received an A.B. degree in chemistry from Harvard University in 1914 and a Ph.D. degree from the same university in 1917. Prior to his association with Kodak, he was an instructor in physical chemistry at the University of Illinois. He was also a National Research fellow at Harvard University from 1919 to 1921 where he did research on the adsorption of vapors on solids.

A member of Sigma Xi, honorary scientific fraternity, Dr. Carver also held memberships in Alpha Chi Sigma, national chemical fraternity; Phi Lambda Upsilon, honorary chemical fraternity; the American Chemical Society; American Association for the Advancement of Science; and the Photographic Society of America which elected him an associate in 1949 and a fellow in 1950. He was a fellow of the Society of Motion Picture and Television Engineers.

During the years of Dr. Carver's service to the Eastman Kodak Company, he contributed much to development and improvement of manufacturing operations. The experimental division which he organized and developed to a position of key importance in the Kodak Park Works involved a unique combination of engineering, chemistry, physics and technical photographic activity. His advice and counsel were sought by all divisions of the company, providing a background which later enabled him to contribute valuable guidance as Technical Assistant to the General Manager of the Kodak Park plant.

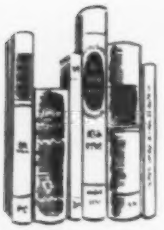
Hosts of friends will remember Dr. Carver as a faithful and true companion, interested in both the technical and human sides of all activities. Always eager to understand the points of view of those who disagreed with him, his greatest satisfactions were in discussing the various

viewpoints of a question to develop its logical conclusions. This often provided a practical and amicable solution to a seemingly irresolvable situation. Emmett Carver believed in living life at its fullest whether at work or play. Many in the Society of Motion Picture and Television Engineers will cherish their associations with him.—*Charles R. Fordyce.*

Harry M. Warner

Harry M. Warner, 76, died July 25, 1958, at his home in Bel Air, Calif. One of the "greats" of the motion-picture world, his career began in 1903 when, with his three brothers, Jack, Albert and the late Sam Warner, he acquired a motion-picture projector and opened a 99-seat theater in Newcastle, Pa. In 1923 he and his brothers founded Warner Bros. and for 33 years he served as its President. He retired in 1956. One of the company's most noteworthy achievements was the production in 1927 of the first "talkie," *The Jazz Singer*, which marked the birth of the era of sound. Born in Poland in 1881, his family emigrated to the United States when he was six years of age. The family settled in Baltimore, Md., and later moved to Youngstown, Ohio, where he opened a bicycle shop. Shortly thereafter he became interested in motion pictures and after opening the Newcastle theater, he exhibited *The Great Train Robbery* and others of the very early films. Shortly before his death he and his brothers were cited by the Motion Picture Pioneers for "vision and enterprise in bringing sound to the screen, for their boundless courage in blazing a new path in screen entertainment and public service and for their unswerving faith in motion pictures and in their industry as a bulwark of the American way of life."

Membership Certificates (Active and Associate members only). Attractive hand engrossed certificates, suitable for framing for display in offices or homes, may be obtained by writing to Society headquarters, at 55 West 42nd St., New York 36, Price: $2.50.



books reviewed

The Technique of Film Music

By Roger Manvell and John Huntley. Published (1957) by Focal Press, London; in U.S.A. by Hastings House, Inc., 151 E. 50 St., New York 22. 300 pp. Illus., 5½ by 8½ in. Price $9.00.

This well-researched work is authored and compiled by Dr. Roger Manvell, Director of the British Film Academy, and John Huntley, in collaboration with a special Committee set up by the Academy under the chairmanship of the eminent English composer William Alwyn who is also responsible for the introduction to the book.

Music always has been and, probably, always will be an integral factor in the production of the motion picture.

This book strives to eliminate the misunderstandings which commonly exist between producer and composer — a rather formidable task — but it does much to clear the music-in-films atmosphere with a very rational approach to the solution of the problem. Possibly the lack of ulcer-inducing experience prevented the authors from a more explicit presentation of the problems of the producer but these seem to be taken for granted and emphasis is placed upon the composer and his (or her) place in the sun. The work is never a fixed format or pattern for either producer or composer — neither is it a meeting of the minds. But the controversial factors that are ever present in the production of a motion picture, music-wise, are dealt with in a discerning if slightly biased manner — biased, that is, in favor of the English composer, naturally.

Stripped of the usual confusing technicalities in a work of this type, *The Technique of Film Music* is arranged, appropriately, in a logical continuity of five sequence chapters: (1) Music and the Silent Film; (2) Music in the Early Sound Film; (3) The Function of Music in the Sound Film; (4) The Music Director and the Sound Recordist; and (5) The Composer's View. The authors point out in substance, that: . . . music, traditionally, was never a novelty in conjunction with films — its appreciation simply has varied. . . . Composition for films is definitely a branch of the art of music. . . . There are, broadly speaking, two main forms of film music — "realistic" and "functional". . . . Today, music in films has become disciplined to a great extent and is considered an essential part of the picture. . . . The film industry is at long last realizing the need of closer integration between music and the other elements in motion-picture production.

Sometimes the authors' insistence on detailed explanation of all aspects of a point at issue takes us on long detours of quotation but for the filmatic student this can be an asset. This is particularly true when the subject dealt with is the documentary film.

There is a veritable wealth of carefully researched and documented material in the Appendices which include a comprehensive outline history of film music dating from 1895 through 1955 — A Selected List of Film Music Recordings — Film Music Criticism — and Select Bibliography.

Even a casual perusal of this work should tend to discourage some producers from the indiscriminate use of unrelated "stock" music tracks in favor of possibly less but better original music directly related to the picture story. Hurried film makers in television, too, would do well to study this timely book. We believe there would be an upcurve in quality, originality and, importantly, treatment of music in this medium were some of its constructive suggestions applied to TV production.

We wish authors Manvell and Huntley could have dealt at some length with the technical pitfalls of scoring music for the newer dimension recording and reproduction systems — but evidently manuscript deadline prevented.

Every serious student of films, and especially music in films, as well as the studio

"pros" will benefit by reading this worthwhile work and it is axiomatic that no good library should be without a copy of it.

The Technique of Film Music is informative, authentic and, often, entertaining reading. —*Solita Palmer* and *Emerson Yorke*, Box 265, South Laguna, Calif.

Miss Palmer (Mrs. Emerson Yorke) is a member of ASCAP and composer of original film music; Emerson Yorke, long active in SMPTE, is now an independent motion-picture and TV producer in Hollywood.

Television in Science and Industry

By V. K. Zworykin, E. G. Ramberg and L. E. Flory. Published (1958) by John Wiley & Sons Inc., 440 Fourth Ave., New York 16. 300 pp. illus. 5½ by 9-in. Price $10.00.

The spectacular growth of broadcast television during the last decade has tended to hide the no less steady increase of the use of television in nonentertainment fields. Books such as *Television in Science and Industry* serve as a reminder, if nothing more, that commercial and scientific applications of television are important now and will become commonplace in the future.

The authors, apparently with enthusiasm, have undertaken to record the growth of closed-circuit television to date and to speculate a bit about the future. How they have done this is revealed by the chapter headings: Closed-Circuit Television in Myth and History; Fields of Application of Closed-Circuit Television; Closed-Circuit Television Apparatus; Achievements of Closed-Circuit Television; and Forecast.

As might be expected, the historical material is slanted, where possible, to the closed-circuit application of television. Interestingly enough, the authors have found evidence in technical material, published before the advent of sound broadcasting, that television had been considered only as an individual service — an extension of one's eye to view otherwise inaccessible things. This concept, of course, is continued into closed-circuit television.

The chapter on Achievements of Closed-Circuit Television presents the fruits of a thorough search of the literature. This reviewer would be surprised to learn that a single reported application had been overlooked. This makes interesting reading as application upon application is disclosed.

The chapter on Apparatus is not up to the standards established in the remainder of the book. Figures 3.23 and 3.26 unfortunately do not represent working circuits due to what seems to have been less than careful preparation. The authors have not distinguished between the simplified waveform sometimes called "industrial sync" and the standard RETMA synchronizing and blanking waveforms. Consequently they have listed equipment improperly as using RETMA standards whenever 525 lines, 2:1 interlace, and 60 fields/sec are employed.

Taken as a whole, this book should be of interest to the executive searching for an answer to the question: "What is closed-circuit television and how might it be of use to me?"—*W. T. Wintringham*, Bell Telephone Laboratories, Murray Hill, N.J.

New Members

The next *Directory for Members* is planned for April 1960. The following members have been added to the Society's rolls since the April 1958 *Directory*. Also listed are those regretfully reported as deceased since the *Directory*. The designations of grades are the same as those used in the Directory. An up-to-date list of the Sustaining Members appears on the outside back cover of each month's *Journal*.

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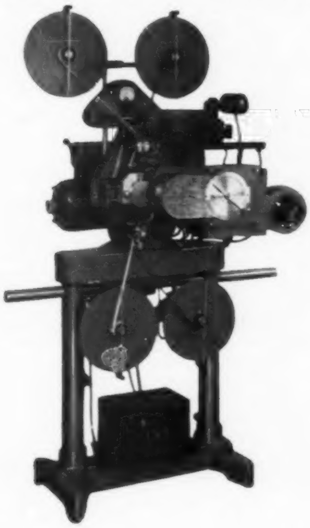

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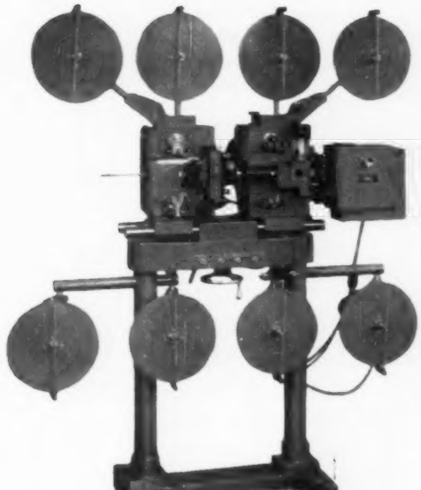

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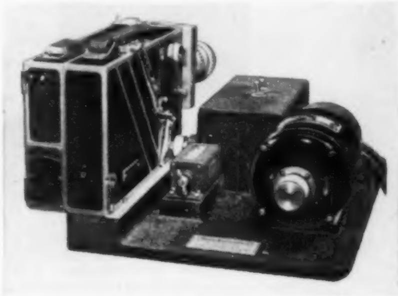

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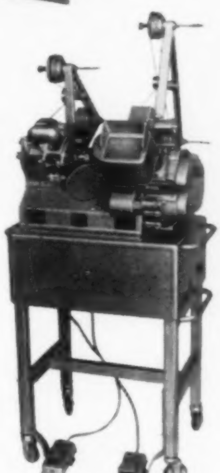

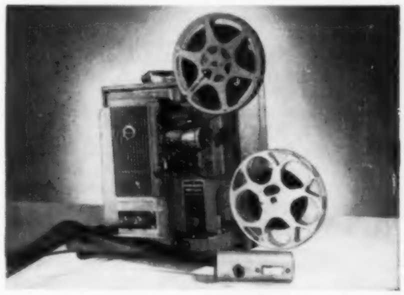

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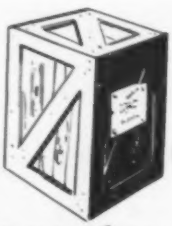


new products

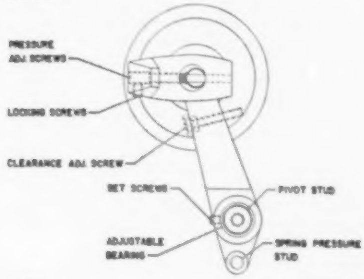
(and developments)

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.

An automatic shutter control and a **printer roller gate** are among recently announced new equipment of Bell & Howell Co., Professional Equipment and Instrument Div., 7100 McCormick Rd., Chicago 45.

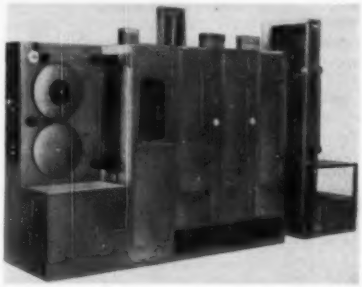
The shutter control has been especially designed to permit the conversion of Model D and J printers for tape-programmed operation without modification of the printer. The control consists of two components: the electro-selector and the tape reader. The selector is mounted to the printer in place of the existing index dial and pointer. The reader is placed on the printer worktable and a few minor wiring changes are made to prepare the printer for automatic operation.

Besides the Automatic Shutter Control Design 6220A, Bell & Howell has announced Design 6170 Program Perforator which uses tape of commercially available 8-hole width to provide scene change information for printer color and density control.



The control makes possible printer light changes every 18 frames of 16mm film at 150 ft/min or every 7 frames of 35mm film at 150 ft/min. Light changes are accomplished through a cam-solenoid arrangement within the electro-selector in response to the coding on a preperforated tape. The operating cam matches the 22 exposure positions of the printer and is driven by a 1725-rpm synchronous motor with a gear reduction to approximately 228 rpm. Decoded signals are fed by the reader to the electro-selector and the selected solenoid engages to halt the rotating cam at the proper exposure position. The solenoid remains engaged until the scene notch in the film releases the exposure information to the shutter. The solenoid then disengages and the reader tape advances to the next set of perforations.

The roller gate, shown schematically above, is designed for economy and ease of installation. Planned to replace the old-style gate shoe on all Design 5205 printers, it is designed to maintain a gentle pressure against the film at the preset position, to allow the roller to ride over splices and to compensate for slight parallel variations between the printer jaw and the gate pivot stud (which may become evident when the roller is used as an accessory on older model printers). It is priced at $115.00.



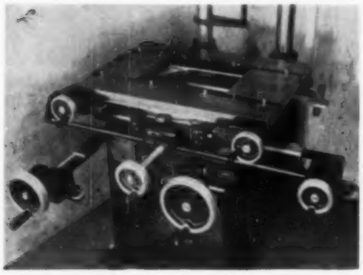
A rapid spray processing machine, Model S-150R, for 16mm and 35mm films has been announced by Filmline Corp., Milford, Conn. The machine processes 16mm or 35mm negative emulsions at 100 ft/min and positive films at 150 ft/min. It can be converted from 16mm to 35mm by moving a film-flange lever. Reported warm-up time is 10 min and dry-to-dry processing cycle 5 min. Speed is adjustable from 25 to 150 ft/min and each processing step can be varied from 48 sec to 5 min. Features include temperature controlled processing for the two banks of film in each chemical cabinet. Each cabinet has its separate refrigeration and heating, recirculation and replenishment systems. The minimum solution requirement is 6 gal. The feed station consists of two 3000-ft flanges, film elevator and alarm with automatic electric brake and a manual brake. Safety features are included. The switch control is on a single panel with separate darkroom section and daylight section operational control. Switches are interlocked. Approximate dimensions are: length, 31 in.; width, 22 in.; and height, 87 in. Dimensions for the daylight section are: length, 105 in.; width, 32 in.; and height, 81 in. It is priced at $31,700.00 completely equipped, or $30,900.00 without refrigeration. It is distributed by Camera Equipment Co., 315 W. 43 St., New York 36.

A new antistatic material for cleaning lacquered or magnetic striped film has been announced by Nicholson Products Co., 3403 Cahuenga Blvd., Los Angeles 28. The new cleaner, Tuff Coat 425A, is said to provide maximum protection from scratches and abrasions. Because of absence of softening action it is also recommended for videotape, recording tape and recording heads. It is priced at $5.50 a qt and $16.00 a gal.

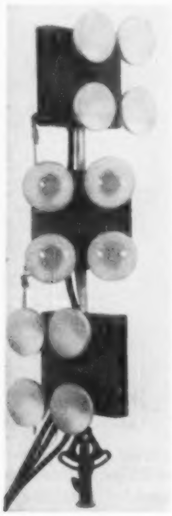
The new Oxberry Animation Stand (Model S—see the *Journal* for May, p. 360) and other Oxberry animation equipment are now distributed exclusively in

Eastern United States by Camera Equipment Co., 315 W. 43 St., New York 36. Model S which was described earlier in some detail is now marketed at $3,950.00.

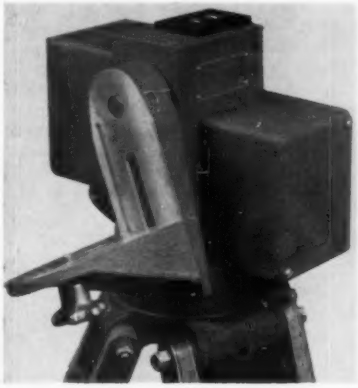
A catalogue of animation equipment is available from Bowlds Engineering, 1507 North Kingsley Dr., Los Angeles 27. The 16-page catalogue illustrates and describes the company's animation stand, accessories and other equipment. The stand features 3 to over 20 field range, a versatile camera mount with full 360° rotation, a 48 by 18-in. table with snap-in-snap-out pegs, self-adjusting electric platen unit and constant argon back lighting. The price of $12,975.00 includes a 35mm or 16mm Acme Animation Camera.



An Animation Compound has been announced by Warren Conrad Portman Co., 41 MacQuesten Pkwy., N., Mount Vernon, N.Y. The compound features 19-in. North-South and 26-in. East-West ball bearing mounted movements. The table top measures 20 in. by 28 in., rotates 360°, has a 9 in. by 12½ in. hole through it for rear projection and is designed for use with any camera stand. It is priced at $1790.00. A 12-page catalog is available upon request.



The Quadlite, a 10-in. square floodlight designed to be used in a small space, is a product of Mole-Richardson Co., 937 North Sycamore Ave., Hollywood 38. The unit, which is 2 in. thick, uses reflector globes as a source. It is mounted on a Baby pedestal and may be tilted in any direction by use of a quadrant, supplied as an accessory. Provision is made for stacking one on another by means of stacking posts. Each socket is controlled by a separate switch. Weight of each unit is 10 lb.



A remote-control pan and tilt assembly has been announced by Camera Equipment Co., 315 W. 43 St., New York 36. Designed for industrial TV and vidicon cameras, suggested uses include high towers, scaffoldings, ceilings, areas of intense heat or cold or areas too small to allow manual control of the camera. Pan and tilt can be operated independently or simultaneously. "Dial-stop" limiting switches permit presetting the travel of the pan or tilt movement. Dimensions are 10 in. by 9 in. by 9 in. and the weight is 14½ lb with a 20-lb capacity. The travel speed is 3° per sec in either direction. The motor requirements are 110-v, 60-cycle a-c. The connectors, Cannon, 6 leads, 1 wire.

A mobile film developing machine which has been continuously used during the past two years by CBS news engineers is now available commercially from Motion Picture Enterprises, Inc., Tarrytown 83, N.Y. The machine, Model MM14, operates on 110-v 60-c current. It can be used in any office or room having hot and cold water or it can be permanently installed in a laboratory. Chemical mixing facilities are built in and solutions have provisions for automatic temperature control and replenishment. Films with negative or positive emulsions are developed at speeds up to 3000 ft/hr. Dimensions are 29 in. high, 36 in. long and 20 in. wide. It is priced at $3980.00.

A 5.7mm $f/1.8$ Kinoptic Apochromat lens has been announced by Karl Heitz, Inc., 480 Lexington Ave., New York 17. The new lens completes a series of 12 color matched 16mm lenses ranging from the 5.7mm of the new lens to 500mm. The lens is equipped with both f- and T-stops and features 3-color correction and wide angle coverage of 113°. Depth of field at maximum aperture $f/1.8$ extends from infinity down to 6 in. The lens can be supplied in Arriflex, Cine-Special or C-mounts. It is priced at $495.00.

The meaning of exposure indexes will be a new part of instructions released henceforth with instruction sheets that accompany Eastman Kodak Co. black-and-white films. Two new paragraphs, aimed at advanced amateurs, will read:

"These numbers are for use with meters marked for American Standard Exposure Indexes. They include a safety factor, intended to prevent underexposure due to variations in equipment and use. If you know your equipment is in good working order, you may wish to eliminate this safety factor by using: *2 times the above numbers for subjects of normal contrast*, still higher numbers for subjects of low contrast. By thus reducing exposure you will obtain negatives of lower density with less grain and increased sharpness.

"If with normal development your negatives are consistently too thin, increase exposure by using a lower number; if too dense, reduce exposure by using a higher number."

A photoelectric 8mm camera which permits the use of interchangeable lenses, various types and speeds of films and variable shutter openings has been introduced by Paillard Inc., 100 Sixth Ave., New York 13. The camera is the Bolex B-8L, called the "20-20 compumatic." In this camera the photoelectric cell is placed behind the lens. The light is measured after it has gone through the lens so that only the light that will affect the film registers on the photocell, thus eliminating problems due to stray light. Features include a double indicator system in which a red needle indicates the amount of light needed with whatever coverage of lens, film and variable shutter opening is being used. A black needle indicates the exact amount of light entering the lens and the aperture of the lens is adjusted until the needles are superimposed to get the amount of light needed for the best exposure. The price range begins at $169.50.

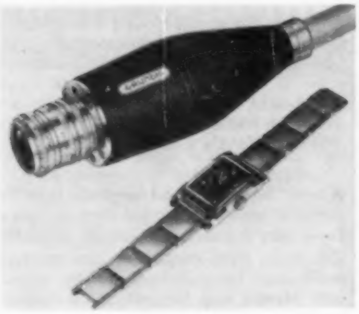
The 398A Special Filmosound is a projector designed especially for audio-visual instruction in churches, schools and industrial organizations introduced by Bell & Howell, 7100 McCormick Rd., Chicago 45. The new projector retains the same mechanism used in higher priced Filmosound units, but has been simplified by removal of clutch and reverse features. The projector has been further simplified by a new rotary dial switch that operates both motor and lamp in one twist, a permanently attached line cord for faster set-ups, and automatic rewind release to prevent film damage. The new projector is priced at $459.95.

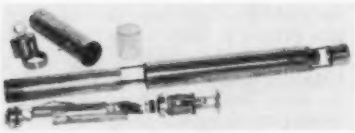
A transmitter for medium-coverage TV stations has been announced by Radio Corp. of America. Designed for economy and to save space, the transmitter is recommended for VHF stations with effective radiated power requirements ranging from 2 to 20 kw. It can be adapted for remote control operations with the addition of suitable terminal equipment. The cabinet is 7-ft high and 6-ft long. The transmitter, named the TT-2BH, is suitable for both monochrome and color TV. The principal meters are mounted in a sloping panel at the top of the cabinet for easier examination. Exciter and modulator units are adjustable from the front.

The Model 1150 Automatic Picture and Sound Generator, designed for closed-circuit TV applications, automatically transmits pictures with sound from 35mm (2×2) slides as recently announced by B&K Mfg. Co., 3726 N. Southport Ave., Chicago 13. A removable slide magazine which shows up to 28 standard 35mm glass slides can be set for automatic, manual or remotely controlled operation. For continuous automatic showing the slide changer recycles itself after the last slide. A variable timer permits selection of automatic time interval from 5 sec to 75 sec. Two audio input channels are provided. The external audio source can be tape, tuner or microphone controlled by a switch. The power input is 117-v 50–60-cycle a-c. Dimensions are 10½ in. by 25 in. by 16¾ in. The price is $895.00.

A TV projector which projects images up to a size of 12 by 15 ft on a flat screen is manufactured by Tela Electronics Div. of the Meilink Safe Co., Ferndale 20, Mich. The projector, called the Giantview, receives and projects pictures from either closed-circuit direct lines or regular station telecasts. Recommended by the manufacturer for use with closed-circuit TV audiences of 100 to 3000, it projects a minimum of 450 scanning lines and can be operated in subdued room light. For off-air pickup, it incorporates a Conrac tuner, and

has two 10-in. speakers for even sound diffusion. Jacks are provided for tie-in to public address systems in larger rooms. It operates off a standard 110-v outlet. Weight, complete with shipping case, is 375 lb. The projectors will be sold or leased through franchised dealers.

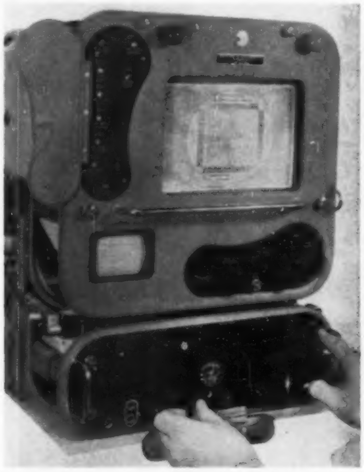




The Grundig Miniature TV Camera, designed specifically for interior observation of pipes, is distributed by L. M. Bleackley, 145 Yonge St., Toronto 1, Ont., Canada. The length of the camera, without lens, is $5\frac{11}{32}$ in. and the diameter at the widest part is $2\frac{3}{32}$ in. Approximate weight is 1.1 lb. The camera utilizes an extremely small vidicon. The resolution, both horizontal and vertical, is approximately 300 lines. The camera is equipped with a fixed-focus lens and a mirror with a 45° tilt. Glowlamps serve to illuminate the wall of the pipe. The current is fed over the camera cable. Applications other than that for which it was specifically designed include internal inspection of airframe components for corrosion or distortion and as an underwater camera.

A high pass–low pass filter which permits direct reading of the frequency dial has been developed by Allison Laboratories Inc., 14185 East Skyline Dr., La Puente, Calif. The machine, Model 420P, is a continuously variable frequency filter with separate high pass–low pass sections, permitting the operator to set up any bandwidth within the range of 20 cycles to 20,000 cycles. It is portable and is designed for 600-ohm circuits. Input and output plug-in transformers are available for matching impedance to vacuum tube circuits.

A cable tester with which complex, branching circuits are simultaneously high potted, tested for continuity and measured for leakage resistance between each circuit and all others has been developed by California Technical Industries, Division of Textron Inc., 1503 Old County Rd., Belmont, Calif. The instrument has calibrated front panel controls that allow independent setting of all test parameters. Checking at a rate of five wires per second in automatic operation, the tester stops when a faulty circuit is found. With the basic tester, the total capacity of tests (branches and main wires) is 200, and the maximum number of these tests that can be used for the branches is 100. Auxiliary equipment can be provided to extend the test capacity indefinitely.



A Semiautomatic Alignment Kit has been announced by Canadian Marconi Co., 2442 Trenton Ave., Montreal, P.Q. Designed for simplicity of operation, the kit can be fitted to most image-orthicon camera chains. A small printed board generates a square wave at half-field frequency which modulates G4 in the orthicon. Operated by a front panel pushbutton, the effect on the picture is to double-up diagonal lines if the tube is out of alignment. Adjustment of the X and Y alignment controls can be quickly performed to arrive at the position of optimum alignment.

An improved version of the Photo-Sonics rotary-prism high-speed recording camera has been announced by Traid Corp., 17136 Ventura Blvd., Encino, Calif. The camera, called the 1B, is designed to take full-frame pictures at speeds up to 1000 frames/sec and to operate under extremes of temperature and vibrations. Picture quality is maintained by means of a rotary prism and disk shutter which turns in synchronization with the continuously moving film. The prism provides image compensation and the disk shutter, located between prism and film, produces even exposure and high-image resolution. Provision for magazines of various capacities permits changes in running time. Applications include missile recording, track sled recording, aircraft flight testing and industrial analysis.

Among other equipment made or distributed by Traid and recently described in its publication *Traid Winds* are the Traid 638 Fotoperiscope relay lens for 16mm cameras and the TN-9 Fotodata Aircraft Camera System. The Fotoperiscope is a 90° photographic periscope. The lens portion of the assembly rotates 360° around the metal extension tube, thus permitting the lens to be aligned and locked into place at any position around the tube's axis. New components added to the basic Fotodata aircraft camera include a correlation counter, a 100-ft magazine with a built-in, two-light timing system and Fotoscope lens.

EOTS Equipment, a 12-page brochure, available upon request from J. W. Fecker Inc., 6592 Hamilton Ave., Pittsburgh 6, Pa., contains a detailed description accompanied by a number of photographs of the Electronic Optical Tracking System developed by Contraves AG, Zurich, Switzerland (*Journal*, p. 238, April 1958). The brochure also describes EOTS accessories. The firm was recently appointed sales and service representative in the United States for the Swiss organization.

A compact and rugged 16mm data camera, called the Thinform Model FDTF-001, has been designed by Fairchild Data Devices Corp., 580 Midland Ave., Yonkers, N.Y. Specifically for flight test research, the camera is 1¼-in. thick and adapted to installation in thin airfoils or, without pods, on the external surfaces of aircraft and missiles. It is 8¾-in. high and the depth from front to rear is 7$\frac{11}{16}$ in. without the connector. It weighs less than 4¾ lb without lens or film. The film transport is intermittent type and operates at speeds of 16, 24, 32 or 63 frames/sec. Frame rates are changed by substituting gear sets. Film capacity is 100 ft in the standard darkroom loading magazine. A slightly larger 100-ft daylight loading magazine and a 200-ft darkroom loading magazine are in process of development.

The camera has been tested to operate properly under the following environmental conditions: acceleration of 25 G on the three major axes; vibration of 20 to 25 cycles/sec at 0.060 d.a. and 56 to 500 cycles/sec at 10 G; 100,000-ft altitude and temperatures ranging from −65 to 150 F.

A Compressed Air Loudspeaker (CAL) developed by RCA to test electronic gear for jet planes, missiles and rocket ships can generate noise of 160 db. The device is a plywood box measuring 5 ft by 5 ft by 6¾ ft with dual horns projecting from the box attached to metal pipes leading to the mechanism. The first high-intensity noise systems used electrical power alone. The compressed air system is believed to be capable of producing the world's loudest controlled noise. Although designed specifically for testing purposes the loudspeaker is expected to be useful in areas of extremely high noise levels, such as jet air fields and in civil defense work.

The Flip is an automatic microfilm searching machine produced by Benson-Lehner Corp., 11930 W. Olympic Blvd., Los Angeles 64. It is designed to locate and display a desired frame in a reel of specially processed 16mm photographic film. By means of a self-contained keyboard, appropriate indexing information is established. Following this entry, the SEARCH bar is depressed. Release of the SEARCH bar causes the equipment automatically to transport and scan the film until the desired frame has been located. Information contained on the selected frame is projected on the viewing screen. Simultaneously, frame identification coinciding with the operator entry is digitally displayed on an illuminated light bank indicator. This serves to verify the frame selection and signal the operator that a new search may be instituted.

A new "Scotch" brand magnetic tape constructed with a thin, low-friction, plastic layer over the magnetic coating to prevent the oxide from contacting the recording head has been announced by Minnesota Mining and Mfg. Co., 900 Bush St., St. Paul 6, Minn. Field tests of the "sandwich construction" tape indicate that it lasts at least 10 times longer than standard tapes and, in some applications, from 30 to 100 times longer. There are three tapes in the series, Nos. 186, 188 and 189. They are recommended for AM and phase detection modulation recording applications, and some FM applications. One advantage of the tape is said to be freedom from dropouts. The new tapes are available in all standard instrumentation widths and lengths.

Microphone Facts, a publication containing practical information and helpful hints about the use of microphones, has been announced by Electro-Voice Inc., Buchanan, Mich. The publication will be mailed, without charge, to operating engineers of radio and TV stations and motion-picture studios.

A News Bulletin issued by the Electro-Mechanical Development Co., 2337 Bissonnet, Houston 5, Tex., announces that the Gevaert Cine Phase "26" 16mm reversal black-and-white film manufactured for use in tissue culture time-lapse microphotography (February *Journal*, p. 124) is now available without processing at a price of $4.50 per 100-ft roll. Processing may be purchased with the film in the form of processing coupons at a price of $3.00 per 100-ft. The *News Bulletin* contains an account of the development of this film and other information for persons interested in this special branch of the photographic art.

Subscriptions to the following magazines may be placed with Camera Equipment Co., 315 W. 43 St., New York 36: *American Cinematographer*, *International Photographer*, *Home Movies*, *Film World*, *P.M.I.*, *Educational Screen* and *Business Screen*. This new service is an expansion of the company's policy of making outstanding publications on photographic subjects easily available to its customers. The present book list includes 69 titles of important books such as *Film and Its Techniques* by Raymond Spottiswoode, the SMPTE publication, *Elements of Color in Professional Motion Pictures* and other standard works on motion-picture and television techniques. The book list and order blank is available upon request from the company.

employment service

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Ambitious Photographer, twelve years experience, stills and motion pictures. Three years Audio-Visual Department, San Diego City Schools. Two years news photographer, editor and writer for NBC affiliate television station. Presently employed by small production unit shooting TV commercials, news features, and industrial films. Desires opportunity to do creative quality work with future in production organization, television station or industrial firm. Resume upon request. David Bash, Apt. 2, 2826 Mission Blvd., San Diego 8, Calif.

Photographic and Optical Engineer. Member of technical staff Bell Telephone Labs 21 yrs; Wollensak Optical Co. 4 1/2 yrs; Fairchild Camera & Instrument Co. 3 1/2 yrs. Familiar with practically every phase of engineering photography. Established primary techniques for complete photographic systems including film processing. Designed high-speed motion-picture and recording cameras. Developed new techniques for use in underwater, aerial, missile, industrial and research problems of motion analysis. Can lecture, sell. Author numerous publications and *Photographic Motion Analysis* (Industrial Laboratory Publishing). Served as consultant to many organizations. Fellow SMPTE and Royal Phot. Soc. Founded SMPTE High-Speed Committee and organized first International High-Speed Congress. Salary open. Will relocate. John H. Waddell, 33 Loretta Dr., Syosset, L. I., N. Y. Tel: WAlnut 1-5469.

Motion-Picture Production. Graduate Brooks Institute, MP course, thoroughly experienced in all phases of camera work, editing, optical and magnetic sound recording, and still photography. Produced industrial and educational films, TV commercials. Familiar with B&W processors. Seeking permanent position or temporary assignments. Free to travel, speak several languages. J. C. Klopping, 312 W. Yanonali St., Santa Barbara, Calif. Tel. WOodland 6-1482.

Cameraman-Editor. Would like to join young progressive film-making organization, foreign expedition or exploration party. Recently discharged from Pictorial Branch, U. S. Army Signal Corps. Experienced in sound recording, laboratory and other phases of the motion-picture field. Age 22, single, free to travel. References and complete resume on request. H. LeRoy Mills, 427 Cherry Ridge, San Antonio, Texas. Tel: DIamond 4-6583.

Studio Engineer. Young man (22), vet., graduate of Studio Training Course—TV Workshop, top scholastic man in class; thoroughly qualified audio engineer, TV cameraman, floor manager, video operator, with knowledge of scenery, special effects, lighting, color TV principles and operations; FCC phone license. Willing relocate anywhere; complete resume on request. Martin Morris, 771 West End Ave., New York 25. Tel: MOnument 6-4962.

Engineer-Photographic. Extensive experience in design and development of military and consumer opto-electro-mechanicals, photographic products and instrumentation. Capable of assuming complete responsibility from creative inception to acceptable prototype. Experienced in manufacturing procedures, design simplicity and parts interchangeability. Seeking project assignment or part-time engagement. Write: R.V.N., 59 New York Ave., Westbury, L.I., N.Y.

Cameraman. Have Bolex H16 equipment; will travel. Age 32. 10 years experience news, travel films, wildlife, etc. Go anywhere, anytime. Jack M. Sullivan, Offtrail Films, P. O. Box 86/3904 Sockwell Blvd., Greenville, Texas. Tel: GLadstone 5 2679/5 1424. Send for Confidential Service Bulletin #4.

Positions Available

Optics Engineer. Chief of section engaged in photographic and optical support of military video reconnaissance program. Knowledge of photographic sensitometry, processing techniques and geometric optics essential. Reconnaissance systems background and mechanical design experience on aerial cameras or motion-picture apparatus desired. Location—Stamford, Conn. Write: CBS Laboratories, 485 Madison Ave., New York 22. Att: H. P. Munday.

Cameraman. Duties primarily as 16mm cameraman with some work in sound and editing. College production unit engaged in producing 16mm sound and color films of an educational nature. Entrance salary $4704 per year. Send resume of background, experience and references to Norman E. C. Naill, Production Supervisor, V.P.I. Motion Picture Unit, War Memorial Hall, Blacksburg, Virginia.

Theatre Sound Engineer. Must have good technical background and be experienced in theatre sound work. We are expanding. Applications will be treated with strictest of confidence. North West Sound Service, Inc., 73 Glenwood Ave., Minneapolis 3, Minn.

Laboratory Quality Control. Requires thorough experience in sensitometric control methods for B&W and color raw stock (print, sound recording and camera) and developing processes. Knowledge of chemical test procedures for processing formulae and operation of temperature control systems. Ability to judge picture and sound quality. Position will be as assistant to Manager in a rapidly expanding laboratory. Send complete resume of professional background, education and salary requirements to: Dana C. Rogers, Southwest Film Laboratory, Inc., 3024 Ft. Worth Avenue, Dallas 11, Texas.

Electronic Engineer (Television Division). Qualifications: Engineering degree or equivalent; 3 yr general electronics and 1 yr television experience; extensive knowledge of vidicon and image orthicon monochrome and color systems, broadcast and closed-circuit systems, kinescope and video tape recording techniques and equipment, and microwave transmitting and receiving video and audio equipment. The incumbent of this position plans, designs, advises upon, coordinates, tests and evaluates development of television equipment, systems and facilities to determine their application in military service. Salary $10,130 per annum. Contact Miss Mary Jane Kerwin, Personnel Management Branch, Civilian Personnel Office, Army Pictorial Center, 35-11 35th Ave., Long Island City 1, N. Y. Tel: RAvenswood 6-2000, ext. 238.

Motion Picture Specialist. U.S. Civil Service Commission announces an unassembled examination for producer-directors, script writers and editors, and film editors for duty with Dept. of Agriculture, Dept. of the Navy and in a few foreign positions. Salaries $4,525 to $8,990. Complete details are in Announcement No. 157 B, obtainable from U.S. Civil Service Commission, Washington, D.C.

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News Columns

Advertisers

Meeting Calendar

National Symposium on Telemetering, Sept. 22–24, Americana Hotel, Miami Beach, Fla.
Standards Engineers Society, Sept. 22–24, Benj. Franklin Hotel, Philadelphia
Fourth International Congress on High-Speed Photography, including Equipment Exhibit, Sept. 22–27, Cologne.
IRE, AIEE, Industrial Electronics Conference, Sept. 24–25, Rackham Memorial Bldg., Detroit, Mich.
Audio Engineering Society, Annual Convention and Exhibit, Sept. 29–Oct. 3, Hotel New Yorker, New York.
10th International Cinematography Engineering Congress, Oct. 2–4, Turin, Italy.
Society of Photographic Scientists and Engineers, Annual Technical Conference, Oct. 6–10, Manger Rochester Hotel, Rochester, N. Y.
Optical Society of America, Oct. 9–11, Hotel Statler, Detroit, Mich.
U. S. National Committee of the International Commission on Illumination (C.I.E.) Annual Meeting, Oct. 13–14, Lion Inn, State College, Pa.
National Electronics Conference, Oct. 13–15, Hotel Sherman, Chicago.
NAEB, Annual Convention, Oct. 14–17, Hotel Sheraton-Fontenelle, Omaha, Neb.
IRE Canadian Convention, Oct. 15–17, Exhibition Park, Toronto, Canada.
84th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 20–24, Sheraton-Cadillac, Detroit.
National Society of Professional Engineers, Fall Meeting, Oct. 23–25, St. Francis Hotel, San Francisco.
AIEE, Fall General Meeting, Oct. 26–31, Penn-Sheraton Hotel, Pittsburgh, Pa.
American Standards Association, Ninth National Conference on Standards, Nov. 18–20, Hotel Roosevelt, New York.
Acoustical Society of America, Nov. 21–23, Chicago, Ill.
American Physical Society, Nov. 28–29, U. of Chicago & Hotel Windermere, Chicago.
Electronic Industries Association, Conference on Reliable Electrical Connections, Dec. 2–4, Statler-Hilton Hotel, Dallas, Texas.
85th Semiannual Convention of the SMPTE including International Equipment Exhibit, May 4–8, 1959, Fontainebleau, Miami Beach.
86th Semiannual Convention of the SMPTE including Equipment Exhibit, Oct. 5–9, 1959, Statler, New York.
87th Semiannual Convention of the SMPTE, May 1–7, 1960, Ambassador Hotel, Los Angeles.
88th Semiannual Convention of the SMPTE, Fall, 1960, Shoreham Hotel, Washington, D. C.
89th Semiannual Convention of the SMPTE, Spring, 1961, Royal York, Toronto.
90th Semiannual Convention of the SMPTE, Oct. 15–20, 1961, Statler, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members were published in the April 1958 Journal, Part II.

sustaining members

of the Society of Motion Picture and Television Engineers

Acme Film Laboratories, Inc.
Alexander Film Co.
Altec Service Company
  Altec Lansing Corporation
Ampex Corporation
Animation Equipment Corp.
Ansco
The Association of Cinema Laboratories, Inc.
C. S. Ashcraft Mfg. Co.
Atlas Film Corporation
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The Ballantyne Company
Bausch & Lomb Optical Co.
Bell & Howell Company
Berndt-Bach, Inc.
Burnett-Timken Research Laboratory
Byron, Inc.
S. W. Caldwell Ltd.
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  CBS Television Network; CBS Television Stations; CBS News; CBS Film Sales; Terrytoons
The Calvin Company
Capital Film Laboratories, Inc.
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Century Projector Corporation
Cineffects, Inc.
Cinema-Tirage L. Maurice
Geo. W. Colburn Laboratory, Inc.
Color Reproduction Company
Comprehensive Service Corporation
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The Daven Company
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DeFrenes Company
DeLuxe Laboratories, Inc.
Desilu Productions, Inc.
Dominion Sound Equipments Limited
Du Art Laboratories, Inc.
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Guffanti Film Laboratories, Inc.
Frank Herrnfeld Engineering Corp.
Hollywood Film Company
Hollywood Film Enterprises Laboratory
Houston Fearless Company
Hunt's Theatres
JM Developments, Inc.
The Jam Handy Organization, Inc.
Jamieson Film Co.
The Kalart Company, Inc.
  Victor Animatograph Corporation
KINTEL (Kay Lab.)
Kling Photo Corp. (ARRI Div.)
Kollmorgen Optical Corporation
Lorraine Orlux Carbons
J. A. Maurer, Inc.
  Precision Film Laboratories, Inc.
Mecca Film Laboratories, Inc.
Mitchell Camera Corporation
Mole-Richardson Co.
Motiograph, Inc.
Motion Picture Association of America, Inc.
  Allied Artists Products, Inc.
  Columbia Pictures Corporation
  Loew's Inc.
  Paramount Pictures Corporation
  RKO Radio Pictures, Inc.
  Twentieth Century-Fox Film Corp.
  United Artists Corporation
  Universal Pictures Company, Inc.
  Warner Bros. Pictures, Inc.
Motion Picture Printing Equipment Co.
Movielab Film Laboratories, Inc.
Moviola Manufacturing Co.
National Carbon Company, A Division of Union Carbide and Carbon Corporation
National Screen Service Corporation
National Theatre Amusement Co.
National Theatre Supply
Neighborhood Theatre, Inc.
Northwest Sound Service, Inc.
Panavision Incorporated
Pathé Laboratories, Inc.
Prestoseal Mfg. Corp.
Producers Service Co.
Radiant Manufacturing Corporation
Radio Corporation of America
Reid H. Ray Film Industries, Inc.
Reeves Sound Studios, Inc.
Charles Ross, Inc.
S.O.S. Cinema Supply Corp.
Shelly Films Limited (Canada)
Southwest Film Laboratory, Inc.
Technicolor Corporation
Titra Film Laboratories, Inc.
Trans-Canada Films Ltd.
Van Praag Productions
Alexander F. Victor Enterprises, Inc.
Westinghouse Electric Corporation
Westrex Corporation
Wilding Picture Productions, Inc.
Wollensak Optical Company